WEEKLY | NEWS IDEAS INNOVATION

24 JAN 2007

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ACN 000 146 921
Tower 2, 475 Victoria Ave, Chatswood,
Sydney, NSW 2067, Australia,
Tel +61 2 9422 2999 Fax +61 2 9422 2725

UK
Lacon House, 84 Theobald's Road,
London, WC1X 8NS
Tel +44 (0) 20 7611 1200
Fax +44 (0) 20 7611 1250

USA
600 Technology Square, Cambridge,
MA 02139
Tel +1 617 386 2190 Fax +1 617 397 2805

201 Mission Street, 26th Floor,
San Francisco, CA 94105
Tel +1 415 908 3348 Fax +1 415 704 3125

Publisher Sunita Harrington

Marketing and PR Coordinator
Nicole Scott Tel +61 2 9422 2893
nicole@newscientist.com.au

National Advertising Manager
David Pope Tel +61 2 9422 8854
david@newscientist.com.au

Subscriptions Marketing Executive
Melinda Briant
Tel +61 2 9422 2038
melinda.briant@reedbusiness.com.au

Production Manager John De Fraia
Tel +61 2 9422 2627 Fax +61 2 9422 2722
production@newscientist.com.au

Graphic Designer Ronnie Lawrence
Tel +61 2 9422 2742 Fax +61 2 9422 2722
ronald.lawrence@reedbusiness.com.au

Australasian Editor Rachel Nowak
Tel +613 9376 1546 Fax 03 9245 7511
rnowak@newscientist.com.au
Sydney Emma Young
emma.young@newscientist.com

Subscriptions
Tel +61 2 9422 2666 Fax +61 2 9422 2633
Australia only Toll Free 1300 360 126
subscriptions@newscientist.com.au

Newsstand
Gordon & Gotch Australia
Customer Service: Tel 1300 650 666
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Service: Tel +64 9 625 3018
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Enquiries
Tel +61 2 9422 2666 Fax +61 2 9422 2633
Australia only Freecall 1300 360 126
enquiries@newscientist.com.au

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UK
Tel +44 (0) 7611 1230
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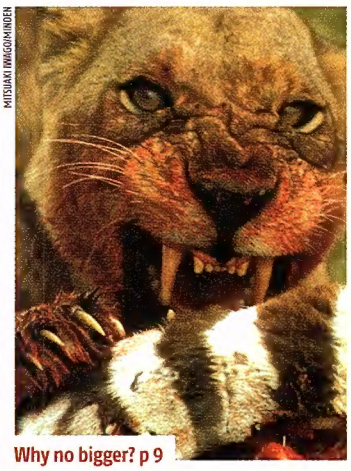

MITSUAKI IWAGO/MINDEN

Why no bigger? p 9

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OPINION

REGULARS

"Ketamine's mind-altering properties may be far more useful than any clubber imagined"

Treating mental illness by "rebooting" the brain, page 38

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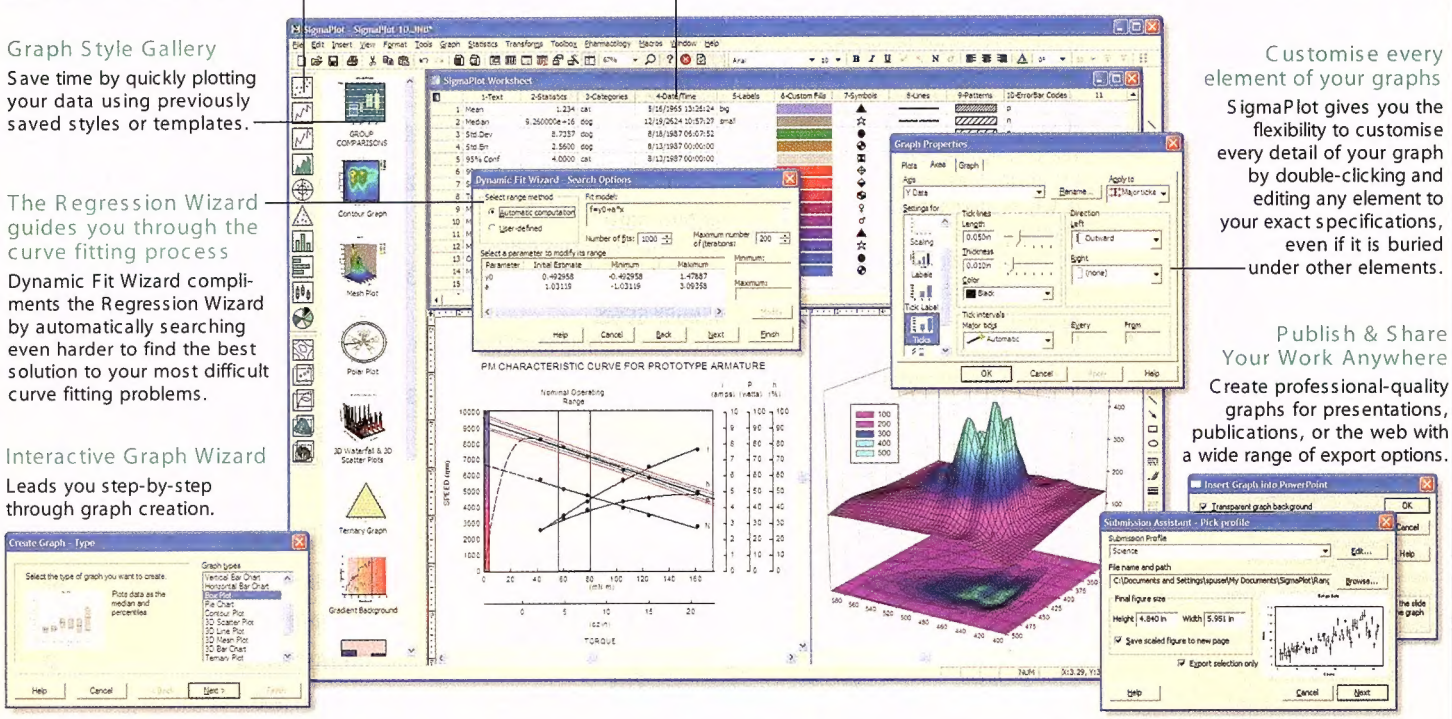

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Editor Jeremy Webb
Personal Asst & Office Manager Anita Staff
Associate Editors
Liz Else, Stephanie Pain

News Editor Matt Walker
Editors Linda Geddes, Rowan Hooper, Anil Ananthaswamy, Helen Knight
Tel +44 (0) 20 7611 1210
Fax +44 (0) 20 7611 1280

Reporters
LONDON Andy Coghlan, Hazel Muir, Paul Marks, Zeeya Merali
news@newscientist.com
BOSTON
US Bureau Chief Ivan Semeniuk
David L. Chandler
david.chandler@newscientist.com
Celeste Biever
celeste.biever@newscientist.com
Gregory T. Huang
greg.huang@newscientist.com
SAN FRANCISCO
Bureau Chief Peter Aldhous
peter.aldhous@newscientist.com
TORONTO Alison Motluk
toronto.office@newscientist.com
BRUSSELS Debora MacKenzie
brussels@newscientist.com
MELBOURNE
Australasian Editor Rachel Nowak
rnowak@newscientist.com.au

Features Editors Ben Crystall, Kate Douglas, Clare Wilson, David Cohen, Graham Lawton, Valerie Jamieson, Michael Le Page, Caroline Williams
Features Assistant Celia Guthrie
Tel +44 (0) 20 7611 1230
Fax +44 (0) 20 7611 1280
features@newscientist.com

Opinion
Editors John Hoyland, Amanda Gefter, Alison George
Opinion Coordinator Eleanor Harris
Tel +44 (0) 20 7611 1240
Fax +44 (0) 20 7611 1280
opinion@newscientist.com
Researcher Lucy Middleton
Editorial Assistant Nick Christensen

Production Editor Mick O'Hare
Asst Production Editor Melanie Green

Chief Sub John Liebmann
Subeditors Vivienne Greig, Ben Longstaff, Julia Brown, Barbara Kiser

Art Editor Alison Lawn
Design Craig Mackie, David Knight, Michelle Ofosu
Graphics Nigel Hawtin, Dave Johnston
Pictures Adam Goff, Ludivine Morel
Tel +44 (0) 20 7611 1268
Fax +44 (0) 20 7611 1250

Careers Editor Richard Fisher
careers@newscientist.com
Tel +44 (0) 20 7611 1248
Fax +44 (0) 20 7611 1280

Consultants Alun Anderson, Barry Fox, Stephen Battersby, Marcus Chown, Michael Brooks, Fred Pearce, Rob Edwards, Mick Hamer, Justin Mullins, Ian Stewart, Gail Vines, Jeff Hecht, Helen Phillips, Gabrielle Walker, Richard Fifield, Bob Holmes, Emma Young, Michael Bond

Press Office
UK Claire Bowles
Tel +44 (0) 20 7611 1210 Fax 7611 1280
US Office
Tel +1 617 386 2190

NEWSCIENTIST.COM
Online Publisher John MacFarlane
Online Editor Damian Carrington
Deputy Online Editor Shaoni Bhattacharya, Gaia Vince
Editors Maggie McKee, Will Knight
Reporters Tom Simonite, Roxanne Khamsi, Kelly Young, David Shiga, Catherine Brahic
webnews@newscientist.com
Special Reports Editor John Pickrell
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No patent? No thanks

There's an anti-cancer drug with huge potential, but no backers

SOME new cancer drugs emerge through better understanding of how the disease develops. Others work in ways we do not understand, and so give us fresh insight. It is rare to find a drug that sweeps away decades of assumptions and reveals a radical approach to treating all forms of the disease.

The drug is a simple, small molecule called dichloroacetate (DCA). Research in Canada led by Evangelos Michelakis of the University of Alberta has shown that it has promising anti-cancer properties. That's not all. The drug's mode of action is also generating excitement.

In 1930, biochemist Otto Warburg proposed that cells turn cancerous by changing the way they generate energy. Normally, cells rely on specialised organelles called mitochondria to supply their energy. Cancer cells switch to a process called glycolysis, which takes place in the body of the cell. It is an inefficient process, used by many bacteria – and marathon runners – when oxygen is in short supply.

Curiously, Warburg found that cancer cells continue to use glycolysis even when oxygen is plentiful. He argued that this fact, now called the Warburg effect, was a defining property of cancer cells. However, the idea did not catch on, not least because another famous biochemist, Hans Krebs, said the Warburg effect was only a symptom of cancer, not its primary cause. This scepticism was reinforced by the belief that cancer cells only switch to glycolysis because their mitochondria fail.

Enter DCA, which has been used for years to treat people with mitochondrial disease. The drug boosts the ability of mitochondria to generate energy. When given to cancer cells, it did the same: it seems that mitochondria in cancer cells are not irreparably damaged after all. What's more, functioning mitochondria help to kill off these aberrant cells (see page 13).

When Michelakis tested the drug on cancer cells in culture, they died. When he gave it to rats with human tumours, the tumours shrank. It appears Warburg may well have been right that the switch to glycolysis is more than just a symptom of cancerous cells.

Best of all, DCA looks like a potential anti-cancer agent. It is cheap, does not appear to affect normal cells, we know its side effects, and it should work on all cancers. But there's a hitch: it is an old drug and so cannot be patented. No pharmaceutical company is likely to fund costly clinical trials without some exclusive rights to make the drug.

This is not a new problem. Many drugs are left on the shelf because companies cannot make lots of money from them. It has happened with drugs for diseases that affect mainly poor people in developing countries, such as TB, though there are now an increasing number of partnerships between governments, charities and commercial companies to deal with these cases. Cancer, by contrast, is chiefly a disease of the rich, and testing DCA will need a one-off effort.

It is a safe bet that drug companies will be falling over themselves to find patentable compounds with a similar action to DCA. Any of these reaching the market will be hugely expensive. It would be a scandal if a cheap alternative with such astonishing potential were not given a chance simply because it won't turn a big enough profit.

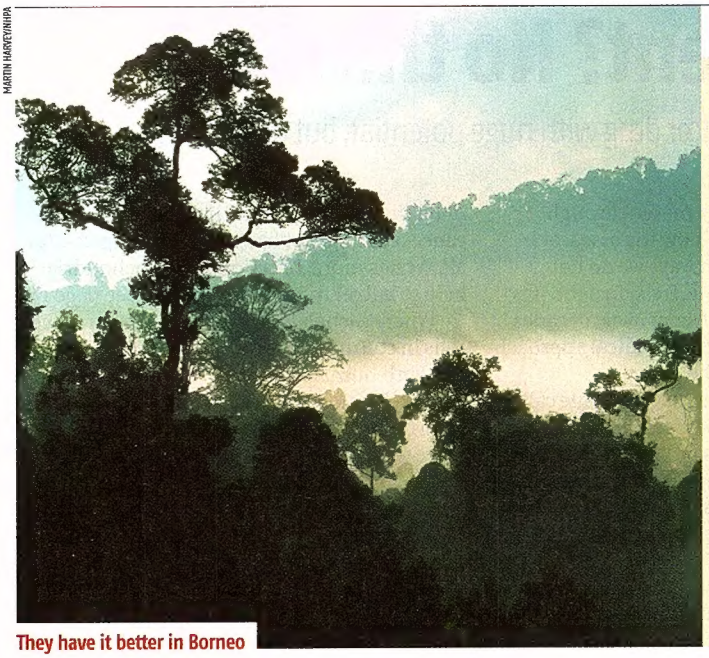
Dietary advice best taken with a pinch of salt

THE saying "one man's meat is another man's poison" could be a motto for the nascent field of nutrigenomics. Everyone has their own selection of genes, some of which cope better or worse with various nutrients. So choose foods to suit those genes and you can avoid disease and optimise your health. Or that's the idea.

There are long-standing examples where this logic is indisputable. People with the single-gene disorder phenylketonuria, for example, must avoid foods containing phenylalanine or risk brain damage. As we have learned more about the human genome, this logic has been extended to other genes and disorders, some involving many genes.

A number of companies have also started to offer dietary advice based on gene tests. To see if the science stacks up, *New Scientist* investigated. The results do not inspire confidence (see page 34). The simple logic of nutrigenomics turns out to be fraught with uncertainties. At present, the best advice to anyone thinking of basing their diet on a limited gene test is "buyer beware".

Upfront



MARTIN HARVEY/NHPA

They have it better in Borneo

A TALE OF TWO FORESTS

For conservationists, it is often a case of two steps forward, one step back. Compare the upturn in fortune for the forests of Borneo with the depressing tale of state government intervention in Mato Grosso, central Brazil.

Since 1996 Borneo has been haemorrhaging 2 million hectares of forest a year to loggers, forest fires and plantations; only half its original forest remains. On 12 January the island's three governments – those of Brunei, Indonesia and Malaysia – agreed at a summit hosted by the Philippines to conserve 22 million hectares of rainforest in the "heart of Borneo", the last large block of forest in the island's interior and the only place in the world apart from Sumatra where orang-utans, elephants and rhinos still coexist.

This is good news for the island's treasure trove of plants and animals: in the past 25 years, 422 new plant species alone have been discovered, according to conservation organisation WWF.

If only the Cristalino State Park were so lucky. The state government of Mato Grosso voted on 11 January to shrink the 184,000-hectare park by 27,000 hectares, allowing loggers free rein. The park is a Mecca for ecotourists, being home to several rare species, such as the harpy eagle and jaguar, not to mention the white-whiskered spider monkey, which is found only in Brazil.

Environmentalists say prospects for other protected areas of Mato Grosso look bleak, as the government is poised to seize a private nature reserve on the park's southern border.

Clone misconduct

THE disgraced South Korean cloning researcher Woo Suk Hwang was not the only bad apple in the bowl: Jong Hyuk Park, a former member of Hwang's team, has now been barred from receiving US federal funds for three years after falsifying separate work.

Hwang's claim to have created cloned lines of human embryonic stem cells imploded in late 2005, when he admitted to irregularities in his data. Less widely reported was the revelation that problems with misconduct extended to other papers published by the lab of Gerald Schatten at the University of Pittsburgh in Pennsylvania. Schatten and others reported Park to the university authorities after realising he had falsified two figures in a paper on this work that they were planning to submit to *Nature*.

The widening scandal leaves a cloud hanging over Hwang's former associates, but Jeanne Loring, a stem cell biologist at the Burnham Institute for Medical Research in La Jolla, California, believes those who were not party to fraud deserve a break. "There's an enclave of very good young scientists," she says.

"Park has now been barred from receiving US federal funds for three years"

Hwang's colleagues at Seoul National University and the nearby MizMedi Hospital – some of which did not bear Hwang's name (*New Scientist*, 24 December 2005, p 4).

Park was involved in the faked human cloning research. When news of Hwang's fraud broke, Park was trying to repeat the supposed cloning feat in rhesus monkeys in

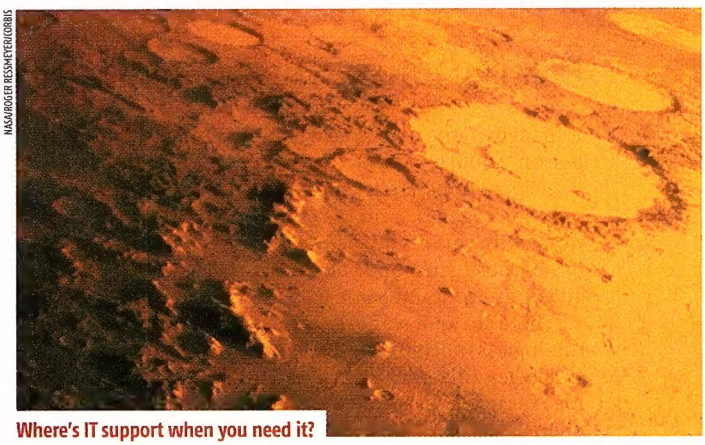
Grandma's legacy

HOW can you prove a chemical is toxic when its effects won't show up until the daughters of the people exposed to it try to have children themselves?

Bisphenol A forms the building blocks of polycarbonate plastics, which are used to make food containers. Small amounts leach from the plastics, and the chemical is commonly found in people. Now researchers at Case Western Reserve University in Cleveland, Ohio, have found that when pregnant mice are exposed to environmental doses of bisphenol A, their female fetuses develop abnormal egg cells (*PLoS Genetics*, vol 3, p e5).

This means the toxic effects will not be seen until those fetuses grow up and try to have offspring. A similar trans-generational effect was seen in the 1970s with the synthetic oestrogen DES, used by pregnant women, which damaged the ovaries of their daughters.

Proving whether bisphenol A has the same effect in humans as in mice could be difficult, because similar chromosomal abnormalities occur naturally. REACH, the new European chemicals law, comes into effect in June, but it could be years before action on bisphenol A is taken.



NASA/ROGER RESSMEYER/CORBIS

Where's IT support when you need it?

Fatal error

IF ONLY NASA's Mars Global Surveyor had an IT expert on board. The spacecraft, missing since last year, may have got lost because of faulty software.

MGS was last heard from in November. In June, NASA's ground controllers had uploaded software to the spacecraft's computer memory – to the wrong location, it now seems.

"Basically, the computer got confused," says Doug McCuistion, NASA's Washington DC-based

director of Mars exploration, although he cautions: "This is a preliminary thought."

The error could have caused the craft's solar array to move to the wrong spot in response to a NASA command on 2 November. The MGS then went into a "safe mode", possibly oriented in a way that left temperature-sensitive components in sunlight for too long, causing a battery to fail and so leaving the spacecraft without enough power to operate.

Staff from the Jet Propulsion Laboratory in Pasadena, California, which manages MGS, as well as people from other NASA centres are to investigate the loss, says McCuistion.

Funds still frozen

SCIENCE was supposed to a big winner when the Democrats took control of the US Congress last November. What is looming first, however, is a fiscal disaster for American scientific research and space exploration.

Republicans and Democrats can share the blame. In 2006, the Republican-led Congress did not finalise the federal budget for fiscal year 2007 (FY2007), so emergency funding went into effect at FY2006 levels until 15 February this year. Last month, the incoming Democrats said

"NASA will not get an extra half-billion dollars it had planned on"

they wanted to continue funding at FY2006 levels for FY2007.

This means that NASA will not get an extra half-billion dollars it had planned on. "Everyone's studying and assessing what the implications would be," says NASA spokesman Bob Jacobs.

NASA is not the only agency in dire straits. The National Science Foundation stands to lose up to $439 million, and the Department of Energy – which funds national research laboratories in the US – will not receive $503 million it had been expecting.

Of cows and coli

CANADA, scene of the worst outbreak of the deadly *Escherichia coli* infection so far, has become the first country to start vaccinating cattle against it.

The virulent 0157 strain infects some 75,000 North Americans a year, up to 16 per cent of whom develop potentially fatal kidney failure as a result. In 2000, some 2300 people in the Ontario town of Walkerton were infected, and seven died. Cattle shed the bacterium in faeces, and people can catch it from contaminated beef, vegetables and water.

Researchers at the University of British Columbia in Vancouver made the vaccine from a mixture of proteins isolated from bacterial cultures. In tests of vaccinated cattle, some were completely protected from *E. coli* infection, while the rest shed far fewer bacteria than unvaccinated cattle. In Nebraska feedlots, the vaccine stopped

"In tests of vaccinated cattle, some were completely protected from infection"

the bacterium from spreading.

Bioniche, an Ontario company, will now manufacture the vaccine, supply it to vets and monitor the results. The researchers hope it will work against other dangerous strains of *E. coli*, as it contains proteins common to all of them.

SURVIVAL OF THE WEIRDEST

This long-eared jerboa (*Euchoreutes naso*), from the deserts of Mongolia, is living on the edge. Now its prospects could be improved by a scheme to protect some of the planet's most unusual creatures.

On 16 January, the Zoological Society of London launched the EDGE programme to focus conservation efforts on mammals that are both evolutionarily distinct – with few close relatives – and globally endangered.

Prioritising species according to the threats they face and their evolutionary relationships is no easy task.

"We're starting with mammals," says Jonathan Baillie, who heads the EDGE team. He hopes to extend EDGE to amphibians in the coming year.

Saving EDGE species will not come cheap, so the team is seeking donations at www.edgeofexistence.org. Work begins this year on 10 mammals, including the long-eared jerboa.

Ominously, an initial search for the top priority, the Yangtze river dolphin (*Lipotes vexillifer*), in the animal's former range drew a blank. "It may already be extinct," says Baillie. "This is a sign that we need to move fast."

JENS SCHLUETER/AFP

Ear today...

Wild birds banned...

A European Union ban on imports of birds caught in the wild will become permanent on 1 July. Conservationists have welcomed the move, saying it will curtail trade in rare species. The temporary ban was imposed in October 2005 after birds in a UK quarantine centre were found to have bird flu.

...and blamed

Migratory birds are probably the cause of an outbreak of H5N1 bird flu that has killed 4000 chickens on a farm in Japan. No people have been infected so far. In Indonesia, backyard poultry farming will probably be banned in an effort to stamp out the disease.

Clouds in your coffee

Some of the world's biggest food companies are inadvertently selling coffee grown illegally in a national park on the island of Sumatra, Indonesia, says a report by WWF. Kraft, Nestlé and Starbucks are among the companies identified as having received coffee from the Bukit Barisan Selatan National Park, home to such emblematic endangered species as tigers and rhinos.

Stem cell support in US

The US House of Representatives passed a bill on 11 January to ease restrictions on federal funding of research on human embryonic stem cells. The Senate will vote on the same measure within weeks. The bill is unlikely to become law, though: the House vote, at 253-174, fell short of the two-thirds majority needed to override an expected presidential veto.

Emissions cuts

Leaders from 16 Asian nations signed a pact on Monday to cut greenhouse gas emissions and develop alternative energy supplies. The agreement capped a summit of the Association of Southeast Asian Nations in Cebu, the Philippines. Meanwhile, oil giant ExxonMobil is engaging in talks organised by an environmental think tank on how to regulate emissions.

This week Climate change

2100: a world of wild weather

The first maps of their kind show how climate change will turn rare disasters into regular events

KATE RAVILIOUS

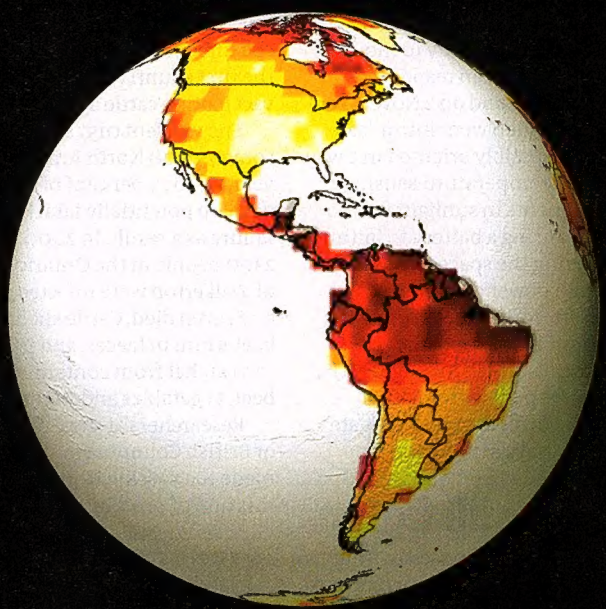
THINK back to the hottest summer you can remember. Now imagine a summer like that every year. For those of us who are still around by the end of the 21st century, this is what we can expect, according to a new index that maps the different ways that climate change will hit different parts of the world. The map reveals how much more frequent extreme climate events, such as heatwaves and floods, will be by 2100 compared with the late 20th century. It is the first to show how global warming will combine with natural variations in the climate to affect our planet.

"We hope it will help policy-makers gain a quick overview of the scientific facts without getting lost in the detail," says Michèle Bättig of the Swiss Federal Institute of Technology in Zurich, who created the index with colleagues after talking to delegates at the 2005 UN Climate Change Conference in Montreal, Canada. The index allows anyone to compare the severity of the predicted effect of climate change on a chunk of the Amazon rainforest, for example, with its effect on a corner of Antarctica.

The results are presented on a global map (see right), in which the areas experiencing the greatest changes are shown in the darkest shades. Swathes of the tropics and high latitudes are coloured a foreboding brown, signifying the most marked changes.

Perhaps the most startling feature is how few areas remain unscathed. "This reinforces what much of the piecemeal climate science is telling us – that many places will face severe challenges," says Neil Adger of the UK's Tyndall Centre for Climate Change Research at the University of East Anglia in Norwich, Norfolk. In the coming decades people in these areas could find it difficult or impossible to adapt to the changed conditions, he adds.

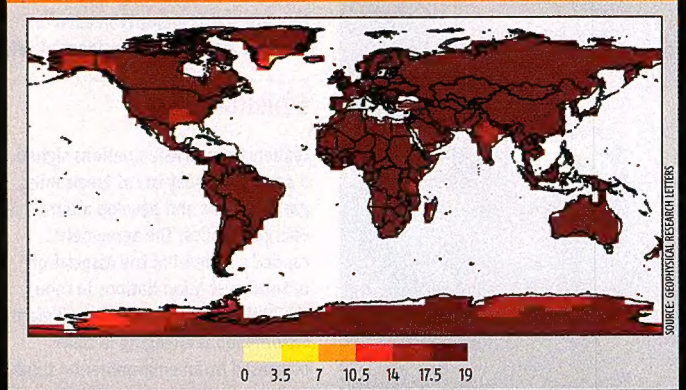
For many parts of the world it seems this trend is already under way. Climate scientists announced last week that 2006 has been the hottest year on record for the US, topping nine years of almost continuous rises. Meanwhile, Europe experienced severe heatwaves in both 2003 and 2006, and for the UK 2006 was the warmest year since records began. Nor does it look as if the mercury is going to stop rising. In an energy technology outlook study published last week, the European Commission warns of stark changes for EU countries over the coming century, including shrinking forests, floods, drought and the drying out of fertile land – unless radical steps are taken to combat climate change.



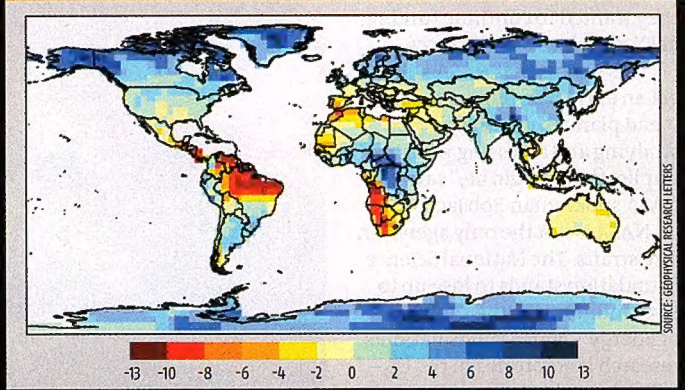
Yet in a global context, even these dramatic changes seem relatively modest. On Bättig's climate change index map Europe, the US and Australia are coloured in shades of yellow and orange, putting them at around 6 or 7 on the scale. Parts of South America's Amazon rainforest and Africa's Congo basin fare much worse, with a predicted climate change index of around 11 (*Geophysical Research Letters*, DOI: 10.1029/2006GL028159).

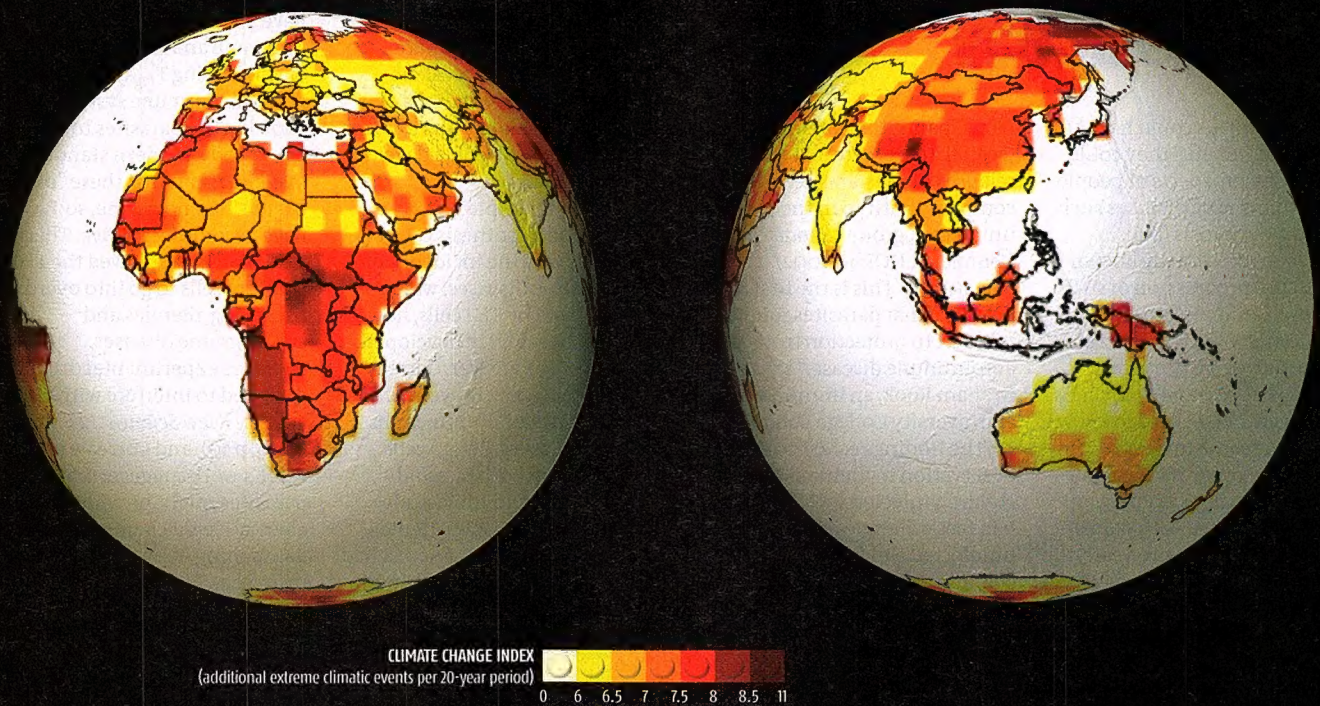
The index was calculated from nine separate indicators of climate change. These included years that are hot, dry or wet overall, and also those in which the months of June, July and August, or December, January and February, would be extremely warm, dry or wet. Bättig and her colleagues divided the world into squares measuring 375 by 375 kilometres, and for each indicator

ADDITIONAL NUMBER OF HOTTEST YEARS WITHIN A 20-YEAR PERIOD



ADDITIONAL NUMBER OF WETTEST (+) AND DRIEST (-) YEARS WITHIN A 20-YEAR PERIOD





they identified the extreme climate events that in the period 1961 to 1990 would have been expected to occur in 1 year in 20.

Using three different global climate models, each based on a mid-range forecast for greenhouse gas emissions, they computed the likely change in frequency of these extreme events during the period 2071 to 2100. The changes were then weighted to provide a single number between 0 and 19 for each grid square. A value of 0 equates to all nine climate indicators remaining as 1-in-20-year events, whereas a value of 19 equates to all climate indicators becoming annual events.

"It is a very striking graphic," says Chris West, director of the UK Climate Impacts Programme at the University of Oxford. While other climate change indices have compared changes in average temperature or precipitation, this is the first global index based on climate extremes. "It focuses the debate on the big events we ought to be worrying about," says Tom Downing of the Stockholm Environment Institute and author of *The Atlas of Climate Change*.

The new index has its limitations. "Places that become hotter will face different problems to places that become wetter, but the index implies that they have the same level of risk," Downing says. Bättig has addressed this problem with separate maps for each climate indicator. The first of these, representing additional hottest years, shows the world in an ominous deep red (see Map, below far left). When it comes to overall temperature, 1-in-20-year temperatures are set to become annual events by the end of this century. "What we take now as a surprise will be normal", says Downing.

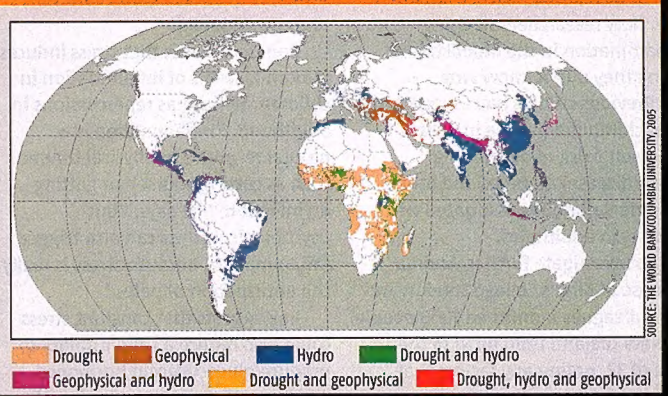
Meanwhile, Antarctica and the Arctic can expect exceedingly wet years to become 13 times more likely, while tropical regions like the Amazon rainforest and the Congo basin will suffer droughts around 13 times more frequently (see Map, below middle left). Rainfall in places in the middle, like Australia and the southern US, is expected to remain fairly close to what it is now. ●

WHERE NATURAL DISASTERS NOW TAKE THEIR TOLL

Climate change is not the same as climate impact, as changes in temperature and precipitation will affect people in some regions far more than others. For example, sub-Saharan Africa is a drought hotspot, while south and south-east Asia are vulnerable to storms and flooding. Any changes in climate here could affect people more severely than, say, those in Europe.

Art Lerner-Lam and colleagues from Columbia University in Palisades, New York, have sketched out which natural disasters pose the greatest threat to life on a global map of their own (see right). They produced their map by combining data on hazard frequency and intensity from the recent past with population density, GDP and geographical factors such as land use. This has already influenced organisations such as the World Bank in deciding which regions should be prioritised for emergency lending.

The next step will be to overlay the extent of climate change, as revealed by Bättig's index for example, and see how this affects the frequency and severity of future hazards. "We are working on this right now," says Lerner-Lam.



A diet of worms could keep MS at bay

PARASITIC worms could have an unexpected benefit: they could improve the prospects of people with autoimmune diseases such as multiple sclerosis (MS).

Parasites are already known to affect the progression of such diseases in animals, so Jorge Correale and Mauricio Farez at the Raúl Carrea Institute for Neurological Research in Buenos Aires, Argentina, wanted to know if they did the same in people. They followed the progression of MS in 24 people, half of whom were recently diagnosed with parasitic infection. For nearly five years, the subjects were checked regularly for any worsening of symptoms, and during the final 18 months of the study their blood was examined for immune cell activity.

Sure enough, those infected with parasites had fewer relapses and less deterioration in their condition than the parasite-free participants, the pair found. Overall, there were just three relapses in the parasite group compared with 56 in the uninfected group (*Annals of Neurology*, DOI: 10.1002/ana.21067). "This is the first direct evidence that parasites might be relevant to protection from an autoimmune disease," says Graham Rook, an immunologist at University College London.

The findings echo the observation in Vietnam that children infected with parasites had fewer allergies than uninfected children (*New Scientist*, 6 January, p 15). They also support a revised version of the so-called "hygiene hypothesis", which suggests that allergies have become more common in recent decades because we are exposed to fewer infections as children.

Bacterial and viral infections trigger a subset of immune cells called TH1 cells, while a different subset called TH2 cells deal with allergies. The assumption was that in developed countries, where micro-organisms are thought to be less prevalent thanks to higher standards of hygiene, the balance tips towards TH2 cells, and so people develop more allergies.

What this simple version of the hygiene hypothesis cannot explain is why the incidence of autoimmune diseases, which are mediated by TH1 cells, has also risen steadily in developed countries. The answer, Correale and Farez suggest, may lie with a different set of immune cells called regulatory T (T_{reg}) cells, which control both TH1 and TH2 responses. In their study, the pair showed that patients with parasitic worms and MS had more T_{reg} cells than people with MS who did not have worms.

Rook has now updated the hygiene hypothesis to take such observations into account. Certain bacteria and parasites have lived with humans for millennia and have evolved ways of stimulating T_{reg} cells to dampen down the immune system, allowing the parasites to survive in the body. Modern standards of hygiene mean that these "old friends" are now gone, so T_{reg} cells have become less active. This in turn may have allowed the TH1 and TH2 cells to go into overdrive, triggering allergies and autoimmune diseases.

> "MS patients with parasitic infections had fewer relapses than those patients who were parasite-free"

Some experimental drugs are designed to interfere with T_{reg} cell activity (*New Scientist*, 23 March 2006, p 10), and Correale and Farez's work suggests that parasites might provide an alternative mechanism for dampening down immune responses. However, Correale cautions that parasites may also induce different regulatory mechanisms. "A better knowledge of the immune response during autoimmunity and parasite infection will allow us to select the best strategy for treatment," he says. **Linda Geddes**

Why childhood trauma brings ill health later on

CHILDHOOD abuse has long been suspected of increasing a person's risk of developing disease later in life. Now researchers studying inflammation in the bloodstream think they might know why.

Previous studies have suggested that childhood trauma increases a person's risk of developing heart disease, diabetes and other disorders normally associated with obesity in adulthood.

To investigate further, Andrea Danese at King's College London and his colleagues monitored 1000 people in New Zealand from birth to the age of 32, noting any factors that created stress, and recorded levels of C-reactive protein in their blood. The protein is a marker of inflammation and has been linked to heart disease.

They found that people who reported having been physically or sexually abused, or rejected by their mothers at a young age, were twice as likely to have significant levels of C-reactive protein in their blood (*Proceedings of the National Academy of Sciences*, DOI: 10.1073/pnas.0610362104).

Danese believes that stress induces abnormal levels of inflammation in children, which has repercussions in adulthood. "Inflammation is a natural response to physical trauma such as cutting yourself or getting an infection," he says, "but psychological stress can also trigger inflammation, because stress is really the anticipation of pain."

He suggests that constant stress could also reduce a child's ability to produce glucocorticoid hormones, which are the main mechanism the body uses to turn off inflammation. His team now plans further work to measure glucocorticoid levels in people who were exposed to stress during childhood.

"This is much stronger than simply saying that people who have a harder time in childhood are more miserable or depressed as adults," says Andrew Steptoe at University College London, who has studied the relationship between emotional triggers and heart disease. "They have elegantly connected childhood stress to a real adult risk of disease."

Danese hopes his work will help people identify those at risk of developing heart disease at an earlier age. Zeeya Merali

LAURENT HAMELS/PHOTO ALTO/JUPITER IMAGES

Her blood will carry the imprint

"Nobody should stop taking statins on the basis of this report... they will be putting themselves at increased risk of heart attack or stroke."

Peter Weissberg of the British Heart Foundation on a small study that found patients with low levels of LDL, or "bad" cholesterol – which can be lowered by statins – to be three times as likely to have Parkinson's disease as those with high levels (*The Daily Telegraph*, London, 15 January)

"I'm prepared to bid for that first ticket to shoot a wolf."

Governor C. L. "Butch" Otter of Idaho, speaking in support of the public hunting of all but 100 of the state's grey wolves after the federal government removes their protection under the Endangered Species Act (Associated Press, 15 January)

"Condoms don't belong in school, and neither does Al Gore."

Frosty Hardison, a parent in Federal Way, Washington, who opposes sex education, speaking out against Gore's film *An Inconvenient Truth*. As a result the city's school board has temporarily banned the film from its schools (*Seattle Post-Intelligencer*, 11 January)

"You want to encourage [sharing milk] but not to the extent of taking milk from strangers."

Jennifer Laycock, who runs a website promoting breastfeeding and milk banks, on mothers who buy milk from each other online without ensuring it is safe (*The Washington Post*, 16 January)

"There is a dark side to this. We felt the exhilaration of discovery, but there was also something scary."

Dennis Schmitt, an explorer from Berkeley, California, on discovering a new island off Greenland that emerged when global warming melted the ice linking it to the mainland (*The New York Times*, 16 January)

MITSUAKI IWAGO/MINDEN

This big, but no bigger

Why giants don't eat meat

BOB HOLMES

EVOLUTION has never fashioned a lion or wolf the size of an elephant. Nor is it likely to, because such a "super-carnivore" would not be able to run fast enough to catch prey big enough to fuel the energy demands of its enormous body.

"You can only be so big as a mammalian carnivore," says Chris Carbone of the Institute of Zoology in London. Carbone and his colleagues trawled the literature for estimates of daily energy intakes and expenditures for different-sized species of carnivorous mammals. As they expected, this showed that larger carnivores used more energy, with every doubling of body weight bringing a roughly 1.6-fold rise in energy needs.

All known carnivores fall into two distinct groups. Those weighing less than about 20 kilograms tend to eat rodents and insects, prey much smaller than themselves, while larger carnivores usually eat prey of roughly their own size or even larger. Hunting and killing these large prey takes a lot of energy, however – more than twice as much as the smaller carnivores need, after accounting for the predator's body size.

Moreover, the largest carnivores within each of the two feeding strategies seemed to struggle to get enough to eat. Both the largest small-prey feeders, such as the aardwolf, and the largest big-prey specialists, such as lions and polar bears, spend much of their time conserving energy by resting or moving slowly, and their total rates of energy intake and expenditure tend to be lower than expected, given their body size. Small carnivore species can evolve larger body sizes by switching to the high-cost, high-payoff strategy of catching big prey, but large carnivores have no better-paying strategy to switch to (*PLoS Biology*, DOI: 0.1371/journal.pbio.0050022).

"If the largest carnivores operate on a tighter budget, this could leave them more vulnerable to threats such as habitat loss"

Extrapolating from this, Carbone's team predicts that no carnivore would be able to make a living if it weighed more than about 1000 kg. Sure enough, the largest carnivore known from the fossil record, the short-faced bear, weighed in at 800 to 1000 kg, and the largest living species, the polar bear, weighs 300 to 600 kg.

Huge flesh-eating dinosaurs such as *Tyrannosaurus rex* had energy needs roughly equal to that of a 1000 kg mammal. The threshold may be different in the oceans, where the greater productivity allows whales to grow much larger, says ecologist James Brown of the University of New Mexico, Albuquerque.

If Carbone is correct that the largest terrestrial carnivores operate on a tighter budget, then this could leave them more vulnerable to threats such as habitat loss or climate change, says John Gittleman, an ecologist at the University of Georgia, Athens. This vulnerability could explain why the largest land carnivores that ever lived are all extinct – and it may suggest which species are at greatest risk of following them. ●

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Invisible physics in action

Dark matter gets its own dark force

THE behaviour of the Bullet cluster – the poster-child for the existence of dark matter – is provoking some cosmologists to propose that there might be a fifth fundamental force.

Most physicists are confident that they have uncovered all the forces that affect ordinary matter: gravity, electromagnetism, and the strong and weak nuclear forces. If there was a fifth force that influenced only dark matter, however, it could easily be at work without us realising, says Glennys Farrar of New York University.

She and her student Rachel Rosen believe they have found evidence for just such a force in the so-called Bullet cluster, which formed when a small galaxy cluster – the "bullet" – smashed into a larger cluster. The collision stripped the two clusters of 90 per cent of their normal matter, which ended up as a pool of gas in the middle (pink in Photo).

Last year, Douglas Clowe, then at the University of Arizona, Tucson, and colleagues analysed the gas-depleted clusters (blue in Photo), found that the clusters still had a huge mass and argued that it had to be dark matter (*New Scientist*, 26 August 2006, p 8).

The story seems to be more complicated than that, however. Farrar's analysis shows that the smaller cluster is moving at around 4700 kilometres per second, far faster than it would if it were moving under the pull of gravity alone. "It's as if it's being accelerated by an extra force that is 20 per cent stronger than normal gravity," she says. Farrar presented the theory at the American Astronomical Society meeting in Seattle, Washington, last week.

"You have to consider the possibility that an extra force is responsible," says Mike Kesden at the University of Toronto, Canada. "If true, it would be an astounding discovery."

Clowe, now at Ohio University in Athens, isn't convinced. "The bullet is certainly moving too fast for the amount of dark matter to explain," he says. "But to invent a fifth force might not be the step that everyone would immediately leap to." He believes that a clump of dark matter from a nearby galaxy cluster could be providing an additional gravitational pull. "The real problem is it's difficult to take just one system as evidence for a fifth force," he says.

Farrar agrees that the Bullet cluster alone cannot convince people that a fifth force is at work, but says that this argument can be turned on its head. "The Bullet cluster is also our only rigorous test of dark matter. If that one test is telling us that there's this big discrepancy with dark matter, people should take notice."

> "It is possible that an extra force is responsible for the speed of the cluster. It would be an astounding discovery"

Tantalisingly, the fifth force could be confirmed or ruled out within the next couple of years, as astrophysical observations are now probing regions of space that would be affected by it. One such observational test has already been carried out by Kesden and his colleague Marc Kamionkowski at the California Institute of Technology in Pasadena. They looked at how dwarf galaxies spiralling around the Milky Way are ripped apart, reasoning that the distribution of stars would be affected by a fifth force (*New Scientist*, 10 June 2006, p 14). "We actually ruled out a fifth force that is as large as Farrar describes, but were looking at a force that acted over a much shorter distance than she did," says Kesden. "It's still possible that a large fifth force acts over larger scales."

Farrar is not convinced that Kesden's work rules out a fifth force even at the scales he examined. She suggests that such a force could explain a related mystery of missing dwarf galaxies: the standard model of galaxy evolution, which uses cold dark matter (CDM) – dark matter moving much more slowly than the speed of light – predicts that hundreds of low-mass dwarf galaxies should be circling the Milky Way, but only tens of such galaxies have been seen (*New Scientist*, 20 August 2005, p 17).

The fifth force would bind dark matter in these dwarf galaxies more tightly than would gravity alone. This would leave ordinary matter – the gas from which stars form and the stars themselves – at the edges of these galaxies less tightly bound than usual, says Farrar. The stars in these dwarfs could easily be ripped out by our galaxy's gravity, and the dwarfs would then contain far fewer stars than expected, making them much harder to observe.

The new force would also pull galaxies into clusters more quickly than predicted by CDM models. This would help explain why we see roughly 10 times more clusters and why the voids between them are far emptier than theory predicts, says Farrar. "There are a number of alternative explanations for each of these phenomena," she says. "But the fifth force is the only explanation that solves them all in one fell swoop." **Zeeya Merali**

THIS WEEK 50 YEARS AGO

Trains to go nuclear

Plans are being prepared by the German railways for an atomic locomotive powered by a gas-cooled reactor using enriched uranium.

The plans envisage a locomotive 35 metres long and 3 metres wide, which will weigh approximately 185 tonnes with an output of 5916 horsepower. The vehicle will be supported on eight axles.

The gas-cooled reactor will make the locomotive much lighter than previously suggested designs because it will not require a refrigerator car and it will be able to omit a number of secondary safety devices – 50 tonnes are saved by using helium as a cooling agent for the reactor and a further 90 tonnes are saved by a reduction in the secondary safety devices. A further weight saving is also possible if the designers elect to use mechanical-hydraulic transmission instead of the heavier electrical type. The reactor will be a Babcock and Wilcox design that is 305 millimetres long.

Instruments will be installed in the locomotive to detect and measure radioactive emanation from the power plant. The crew will be provided with special clothing, and the driving compartment will be insulated against radiation, noise and heat.

The running costs of the locomotive are expected to be lower than the cost of operating a steam locomotive in Western Germany but somewhat higher than an electric one. No information is yet available about when construction will begin nor when the new design is likely to come into passenger service.

Female engineer joins institute

A woman has been elected a full member of the Institute of Civil Engineers for the first time since its foundation in 1817. She is Miss Mary Isolen Fergusson of consulting engineers Blyth and Blyth. She has been responsible for the design of over £2 million-worth of engineering works.

From *The New Scientist*, 24 January 1957

Cheap, safe drug kills most cancers

ANDY COGHLAN

IT SOUNDS almost too good to be true: a cheap and simple drug that kills almost all cancers by switching off their "immortality". The drug, dichloroacetate (DCA), has already been used for years to treat rare metabolic disorders and so is known to be relatively safe. It also has no patent, meaning it could be manufactured for a fraction of the cost of newly developed drugs.

Evangelos Michelakis of the University of Alberta in Edmonton, Canada, and his colleagues tested DCA on human cells cultured outside the body and found that it killed lung, breast and brain cancer cells, but not healthy cells. Tumours in rats deliberately infected with human cancer also shrank drastically when they were fed DCA-laced water for several weeks.

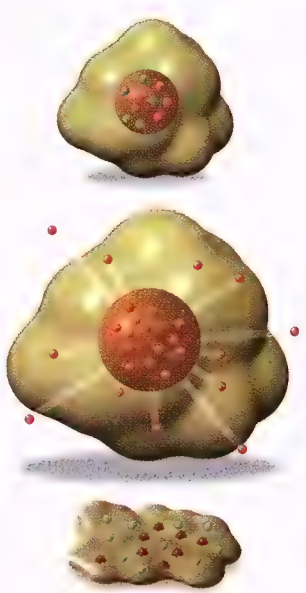
DCA attacks a unique feature of cancer cells: the fact that they make their energy throughout the main body of the cell, rather than in distinct organelles called mitochondria. This process, called glycolysis, is inefficient and uses up vast amounts of sugar.

Until now it had been assumed that cancer cells used glycolysis because their mitochondria were irreparably damaged. However, Michelakis's experiments prove this is not the case, because DCA reawakened the mitochondria in cancer cells. The cells then withered and died (*Cancer Cell*, DOI: 10.1016/j.ccr.2006.10.020).

Michelakis suggests that the switch to glycolysis as an energy source occurs when cells in the middle of an abnormal but benign lump don't get enough oxygen for their mitochondria to work properly (see Diagram). In order to survive, they switch off their mitochondria and start producing energy through glycolysis.

KILLING CANCER

What makes cancer cells different – and how to kill them



Normal cells (blue) in the middle of a benign growth are starved of oxygen but can survive by switching to glycolysis, a different way of making energy. In the process the mitochondria, which contain the cells' self-destruct mechanism, switch off. This makes the cells "immortal" and cancerous (red), so they carry on replicating and the tumour grows

Glycolysis also generates lactic acid, which lets the cancer cells eat through tissue, escape and form secondary cancers elsewhere in the body

A drug called dichloroacetate switches the mitochondria in the cancer cells back on (blue) so they halt glycolysis and start making energy in mitochondria again. The self-destruct mechanism is then activated, and the cells wither and die (brown)

Crucially, though, mitochondria do another job in cells: they activate apoptosis, the process by which abnormal cells self-destruct. When cells switch mitochondria off, they become "immortal", outliving other cells in the tumour and so becoming dominant. Once reawakened by DCA, mitochondria reactivate apoptosis and order the abnormal cells to die.

"The results are intriguing because they point to a critical role that mitochondria play: they impart a unique trait to cancer cells that can be exploited for cancer therapy," says Dario Altieri, director of the University of Massachusetts Cancer Center in Worcester.

The phenomenon might also explain how secondary cancers form. Glycolysis generates lactic acid, which can break down the collagen matrix holding cells together. This means abnormal cells can be released and float to other parts of the body, where they seed new tumours.

> "Once reawakened by DCA, mitochondria order the abnormal cancer cells in a tumour to die"

DCA can cause pain, numbness and gait disturbances in some patients, but this may be a price worth paying if it turns out to be effective against all cancers. The next step is to run clinical trials of DCA in people with cancer. These may have to be funded by charities, universities and governments: harmaceutical companies are unlikely to pay because they can't make money on unpatented medicines.

The pay-off is that if DCA does work, it will be easy to manufacture and dirt cheap.

Paul Clarke, a cancer cell biologist at the University of Dundee in the UK, says the findings challenge the current assumption that mutations, not metabolism, spark off cancers. "The question is: which comes first?" he says. ●

Loner stakes claim to gravity prize


NASA

Mars Global Surveyor was the giveaway

STUART CLARK

A LONE researcher working with borrowed data may have pipped a $700 million NASA mission to the post by being the first to measure an obscure subtlety of Einstein's general theory of relativity.

The phenomenon in question is the Lense-Thirring effect, a small force produced as the fabric of space-time gets twisted by a spinning mass such as a rotating planet. The force will drag the point at which a polar-orbiting satellite crosses the planet's equator by a small amount each year. In April 2004, after 40 years of funded development, NASA launched Gravity Probe B to measure the effect of this force on precision-engineered gyroscopes. A final analysis of the data it collected is still to come.

Now Lorenzo Iorio of the University of Bari in Italy says he has found evidence of the effect in data prepared by Alex Konopliv of NASA's Jet Propulsion Laboratory in Pasadena, California, and his colleagues. To showcase just how sophisticated NASA's grasp of Mars was becoming, Konopliv's team modelled the orbit of the Mars Global Surveyor craft, accounting for such factors as atmospheric drag and solar radiation pressure. They then compared the model with the real orbital data and produced a graph of "residuals", which quantify the difference between the real and modelled orbits.

"When I saw that graph I realised that I could look for the Lense-Thirring effect in the residuals," Iorio says. It was the only gravitational effect that Konopliv's team had not modelled. After grinding through the mathematics, Iorio found that in five years the Global Surveyor's orbit had been dragged around by 1.6 metres. It looked like a clear signature of the Lense-Thirring effect, though slightly smaller than predicted by theory (www.arxiv.org/gr-qc/0701042). Iorio is unconcerned by this discrepancy, which he believes is probably caused by small errors in Konopliv's original model rather than by some exotic new physics.

> "Claims of this importance need to be supported by rigorous error analysis, and it's not clear this standard has been met"

The result has intrigued the Gravity Probe B team. James Overduin, a team member at Stanford University, California, likes Iorio's idea but remains sceptical about the details. "Experimental claims of this importance need to be supported by rigorous error analysis, and it's far from clear that this new [work] by Iorio meets that standard," he says. "A more serious treatment would be of significant interest."

Iorio believes that new tests of the Lense-Thirring effect will soon be possible thanks to the precise orbital data that NASA is collecting for the Mars Odyssey spacecraft. ●

Hybrid flu virus in near-miss escape

A LAB accident has revived fears about experiments that mix human and bird flu viruses and the risk that modified viruses will escape. No virus was released, but the incident has led to a call for details of accidents to be more widely publicised.

Last April, a researcher at the University of Texas, Austin, put tubes into a centrifuge to separate out their contents, which included a human flu virus modified to carry a gene from H5N1 bird flu. The centrifuge became unbalanced and stopped, and when the researcher opened it he found the lid of a safety cup holding one of the tubes had fallen off.

Fearing that the tube inside had leaked, the researcher disinfected everything and called the lab's safety officers. He was wearing a protective hood and respirator, and the whole room was at negative pressure to prevent leaks to the outside. But the researcher had made one mistake: he opened the centrifuge and removed the samples without waiting the recommended 30 minutes to allow any virus-laden aerosol to settle.

In fact, the tube was intact. But if aerosol had escaped, the consequences could have been serious, since the virus would have been able to infect humans, with unknown effects. Experiments since the accident show that the virus replicates more slowly in the lab than human flu, says Bob Krug, head of the Austin lab. But its behaviour in people might be different, and an escapee could also share its new gene with other flu viruses. Such research has been criticised for creating unpredictable viruses that may never emerge naturally (*New Scientist*, 28 February 2004, p 6).

"The University of Texas dodged a bullet," says Ed Hammond of the Sunshine Project, an Austin-based pressure group. He says the incident only came to light because he demanded to see the university safety committee's records. The committee was not unduly secretive, and plans to publish its minutes, but Hammond says more government oversight and public disclosure is needed from labs handling dangerous microbes. Debora Mackenzie ●

In brief

MICHAEL ZUSTEN/MODEL PUBLIC

Test for infection could spare babies from hidden danger

A SIMPLE test could identify inflammation caused by infection in the wombs of mothers showing signs of premature labour, potentially allowing doctors to intervene and prolong their pregnancy.

Routine tests can easily miss infections in the womb, which are one cause of premature births. Such babies often have learning difficulties or, in rare cases, severe brain damage. Catalin Buhimschi of Yale University School of Medicine and his team looked for proteins characteristic of inflammation in samples of amniotic fluid taken from 169 women admitted to hospital because they had gone into early labour or because their waters had broken prematurely. The samples were taken by amniocentesis, in which a long hollow needle is inserted through the abdominal wall and into the womb.

The presence of infection could be confirmed within 15 minutes of testing, and the test picked up even low levels of infection (*PLoS Medicine*, DOI: 10.1371/journal.pmed.0040018).

The technique would primarily be used on women going into labour at between 20 and 34 weeks of pregnancy, where the risk to the child of an undiagnosed infection is much greater than the risk of miscarriage due to amniocentesis. Doctors might then be able to treat the infection using antibiotics, steroids or anti-inflammatory drugs in the hope of maintaining the pregnancy.

Aliens need a lot more time to find us

"SO, WHERE is everybody?" Nobel laureate Enrico Fermi reportedly quipped to fellow physicists in 1950, when discussing why we haven't seen any signs of alien civilisations if, as many believe, our galaxy is teeming with life. Now, a maths model may have an answer to Fermi's paradox.

Rasmus Bjørk of the Niels Bohr Institute in Copenhagen, Denmark, has calculated that eight probes – travelling at a tenth of the speed of light and each capable of launching up to eight sub-probes – would take about 100,000 years to explore a region of space containing 40,000 stars. When Bjørk scaled up the search to include 260,000 such systems in our galaxy's habitable zone, the probes took almost 10 billion years – three-quarters the age of the universe – to explore just 0.4 per cent of the stars (www.arxiv.org/astro-ph/0701238v1).

So, Bjørk's answer to the Fermi paradox: aliens haven't contacted us because they haven't had the time to find us yet.

He adds that the search could be optimised by visiting only those stars that harbour habitable planets, which could be identified by planet-finding missions such as NASA's Terrestrial Planet Finder. Bjørk is also "cautiously optimistic" about listening out for aliens with radio telescopes.

Age takes its toll...

THE gradual erosion of telomeres, the DNA caps at the ends of chromosomes, may signal an increased risk of heart disease.

In a study of about 1500 men, those with shorter telomeres in their white blood cells turned out to be more susceptible to heart attacks than those with longer telomeres.

The cholesterol-busting drugs called statins seemed to weaken the link, but only in people with comparatively short telomeres. "Without statins they might have been even shorter," says Nilesh Samani of the University of Leicester, UK, who led the research (*The Lancet*, vol 369, p 107).

The link could arise because degraded telomeres in blood cells that normally help repair damaged arterial walls might be making these cells less effective. It might one day give doctors a test to identify people at greatest risk, enabling them to get treatment early.

...but it's not so bad to be fat

ANOTHER risk factor for heart disease (see story above) is obesity, but if your heart is already failing, being fat could save your life.

Gregg Fonarow of the University of California, Los Angeles, and his colleagues looked at the records of more than 100,000 patients hospitalised because their heart failure was worsening. They found that the fatter the person, the less likely they were to die during a week-long hospital stay (*American Heart Journal*, vol 153, p 74).

Fonarow suggests that fat people may cope better with heart failure because they have more metabolic reserves to draw on when the heart isn't pumping blood fast enough to meet the body's needs.

Blue-eyed men have clear view of their ideal partner

JEALOUS man seeks partner for meaningful relationship. Tall, handsome, blue eyes, looking for blue-eyed women only.

Why? Because men with blue eyes are drawn towards blue-eyed women, and prefer to choose them as their partner because this can provide reassurance that the woman's babies are theirs too.

When surveyed, blue-eyed men find pictures of women with the same eye colour significantly more attractive than those with brown eyes, whereas neither brown-eyed men nor brown-eyed women show any preference for eye colour, Bruno Laeng of the University of Tromsø, Norway, and his team have discovered.

The effect is seen in real relationships, too. Blue-eyed men are more likely to be romantically involved with a woman of the same eye colour than they are with brown-eyed women, or brown-eyed men are with a partner of any eye colour (*Behavioral Ecology and Sociobiology*, vol 61, p 371).

Blue eyes are a recessive trait, Laeng explains, so two blue-eyed parents should produce a blue-eyed child, while a child with any other eye colour must have been fathered by another man. Blue-eyed men seeking a partner unconsciously know this, Laeng claims, and select women of similar eye colour to ensure they can more easily spot if they have been cuckolded.

PURESTOCK/JUPITER IMAGES

How brain protein turns toxic in Alzheimer's disease

THE long-suspected link between Alzheimer's disease and abnormalities in the way amyloid protein is processed in the brain has been confirmed at last.

Usually harmless, the amyloid protein is thought to trigger neurological damage when it is broken down and transformed into toxic fragments of beta-amyloid. Previous studies have shown that people with Alzheimer's have reduced levels of several proteins involved in processing amyloid.

To find out whether low levels of any of these proteins could cause the production of toxic beta-amyloid, Peter St George-Hyslop at the University of Toronto in Canada and colleagues studied the DNA of 6861 people, 46 per cent of whom had Alzheimer's (*Nature Genetics*, DOI: 10.1038/ng1943).

Those with the disease proved significantly more likely to have variants of the gene *SORL1*, which usually produces a protein that binds amyloid and transports it to an area of the cell where it can be harmlessly recycled.

To demonstrate that mutations in *SORL1* could trigger the disease, the researchers treated cells in the lab to deactivate the gene. This led to a substantial increase in the production of toxic beta-amyloid. "Where *SORL1* is absent or defective, it allows the amyloid to float off into other areas where it is degraded," says St George-Hyslop.

The team have identified two regions of *SORL1* they believe harbour the disease-causing mutations, but have not yet found the mutations themselves.

Chemical trigger for reproduction

MALE hamsters' urge to mate is switched on by the same chemical that triggers puberty in humans.

Greg Demas at Indiana University in Bloomington and his colleagues found that the peptide kisspeptin is involved in switching fertility on and off in Siberian hamsters (*Phodopus sungorus*), which only breed in summer. In winter, male hamsters change colour, their gonads retract and they have no libido. Kisspeptin is one of the triggers for human puberty (*New Scientist*, 22 July 2006, p 34).

One group of male hamsters was exposed to eight weeks of long, summer-like days and another group to short, winter-like days. Demas and his team then measured the amount of kisspeptin in a part of the brain involved in reproductive behaviour.

Those animals that had been exposed to long days were reproductively active and had significantly more kisspeptin than those that had been through an artificial winter. An injection of kisspeptin was also enough to relaunch fertility in the "winter" hamsters (*Endocrinology*, DOI: 10.1210/en.2006-1249).

ALY SONG/REUTERS

Did the new moon lose its iron heart?

THE moon may not be just a chip off the old planetary block. It could have formed at the same time as Earth from the same primordial stuff.

The current theory says that the material that now forms our moon was ejected when Earth was struck by another planet-sized body. But Peter Noerdlinger at Saint Mary's University in Halifax, Canada, says this theory has problems. "The collision has to be implausibly gentle. You practically need someone to hold a Mars-sized object just above Earth and drop it, to avoid messing up Earth's orbit."

The simpler idea that Earth and the moon were both created from the same gas cloud had been rejected because it could not explain why Earth formed an iron core and the moon did not. Now, Noerdlinger has an answer for that.

He suggests that the proto-moon did have an iron core, but that the satellite was ripped apart in a close encounter with Earth. His calculations show that iron from the core would be pulled towards Earth, while the remains of its rocky outer shell reassembled into our iron-free moon.

This fits with evidence that the Earth acquired a veneer of iron after it formed, Noerdlinger says. He presented the work at the American Astronomical Society meeting in Seattle, Washington, last week.

Over-egging the clones

Scientists rushed to make grand claims for hybrid cloning at the first hint that it might be curtailed. They should behave more responsibly, says **Donald Bruce**

UNTIL the end of last year, fusing human cells with animal eggs to create "hybrid" cloned embryos was considered an obscure area of reproductive science, not key to the future of stem cell science. That all changed, it seems, with the publication of the UK government's white paper on embryo research, which prompted politicians, Nobel laureates and the research establishment to line up in support of hybrid embryos as though the future of stem cell research depended on it. The clamour continued until last week, when the UK's Human Fertilisation and Embryology Authority (HFEA) announced it would hold a public consultation on whether such research should be allowed.

Having followed developments in this field closely since 1998, I have found myself troubled by the recent debate. Firstly, why is the science community presenting such a united front about a technology that is still acknowledged as doubtful? When the US biotech company Advanced Cell Technology claimed to have created a cow-human hybrid in 1998, it was viewed as an oddity. Furthermore, reprogramming human cells back to an embryonic state is difficult enough using human eggs; using animal eggs would introduce more uncertainties.

In 2000 when the UK government's expert working group on stem cells gave the green light to cloning embryos for stem cell research, it concluded that while the shortage of human eggs would rule out therapeutic cloning as a basis for treatment, using the eggs of another species "would raise many technical and ethical issues. Most researchers active in this field do not regard this as a realistic or desirable way forward." The government agreed, announcing it would introduce legislation to ban the mixing of human cells with animal eggs, and called on funding bodies "to make it clear that they will not fund or support research involving the creation of such hybrids".

The technical questions over hybrid cloning have not gone away, and it seems disingenuous of scientists to now claim that blocking such research would hinder the search for cures. Most stem cell research projects use spare IVF embryos, of which there are tens of thousands. Those researchers applying for HFEA permission to use animal cells require them not to develop stem cell lines for patients, but for speculative research that is probably decades from clinical application.

There are issues over which politicians and scientists might rightly jump up to defend the cause of science, but this is not one of them. In a country that already has the most permissive legislation in Europe in this area, manning the barricades when the ends do not clearly justify the means may be unwise and could cost public support.

The ethical aspects of the debate also raise serious questions. Scientists are claiming that it is ethically better to use animal eggs because obtaining eggs from women is a highly invasive procedure. However, you don't solve one ethical issue by creating another.

"Some researchers evidently believe these are just cells in a dish, with no moral status"

It's surprising how quickly some scientists have dismissed ethical concerns over mixing animal and human cells, especially when the UK Department of Health cites "ongoing and widespread [public] support for a ban". For some people this research might conjure up unrealistic visions of mythological chimeric creatures, but there is a more valid point at issue: should we be mixing reproductive entities in this way, even if the result will never develop into something capable of producing offspring?

Some researchers evidently believe that these are just cells in a dish, with no moral status, to which we may therefore do what we like. Yet this is out of step with UK law, which takes the view that human embryos, while not having the status of people, should be accorded moral status above that of cells. If that is so, then hybrid embryos derived from human nuclear DNA and animal cytoplasm also have moral status. What is it, and should we create them or do research on them?

The way some scientists are dealing with such questions is reminiscent of the debate over genetically modified food 10 years ago, when they sought to educate the public that any concerns were misplaced. It seems unwise to impose such a reductionist view on the population, or to dismiss those who feel that this is a threshold we should not cross. These are not morally trivial questions, and it is in scientists' own interest to consider them properly.

For Christians such as myself, compassion for the sick is a great motivation for medical research, but within moral limits. In the Church of Scotland, we support some stem cell research with human embryos and might even countenance cloning embryos from human eggs under exceptional circumstances, but we draw an ethical line at mixing human and animal reproductive cells. This resonates with UK law itself, which says that embryonic research should only be used in pursuit of extremely important medical goals achievable no other way. We should think twice before assuming that animal-human cloning is a case in point. ●

Donald Bruce is director of the Society, Religion and Technology Project of the Church of Scotland

Letters

Placebo problems

From David Armstrong
As a practising physician in the UK's National Health Service, I would love to be able to prescribe "pure" placebos occasionally, when I feel it is in my patient's best interest (16 December 2006, p 42). A multitude of factors, however, prevent me doing so.

The trusts that manage hospitals are terrified of anything that smacks of paternalism, or over which they might be sued by a disgruntled patient – so they would not allow it. I am sure that the General Medical Council, which regulates my profession, would take a similar view.

Current dogma is that patient, not doctor, knows best, and that the use of pure placebo would be legally regarded as deception. I do not know of a pharmacy that would dispense a pure placebo, as they, too, are tightly bound by regulations governing cost and "evidence-based prescribing".

As a result, I am sometimes forced to prescribe "impure" placebos – vitamins and the like. I often see pleasing results in cases where there is a significant psychological component to the symptoms. This has always struck me, however, as being in some ways a greater deception than using a "pure" placebo.
Carrickfergus, County Antrim, UK

Doesn't smell right

From Albert Donnay, MCS Referral and Resources
Thank you for exposing the still mostly secret extent to which the developers, manufacturers and purveyors of scented products and scented environments are attempting to manipulate consumer behaviour through smell (16 December 2006, p 36). Although the odours to which consumers are being exposed may not be "drugs" in the opinion of psychologist Rachel Herz, they do meet the US Food and Drug Administration's definition: they are physiologically active chemicals intended to affect human behaviour.

Regardless of their odour, they contain volatile ingredients that are readily absorbed by the blood via the lungs, by the brain via the olfactory nerve, and even by the skin and eyes. Given that the risks of chronic exposure to synthetically scented products and environments are unknown, and that even brief exposures produce acute symptoms in people with chemical hypersensitivity disorders such as asthma, migraine and multiple chemical sensitivity (MCS), I urge consumers to boycott such products and environments.
Lutherville, Maryland, US

From Steve Chalmers
Thank you for making visible the use of fragrances in retailing. I am so sensitive to some fragrances that even sub-odour-threshold doses can trigger my cough variant asthma. I can become slightly intoxicated – even getting the hangover afterwards.

As a result, retail spaces into which fragrances are dispensed, even at levels I cannot smell, are in effect inaccessible to me. Disability legislation mandating accessibility would seem to apply.

These fragrances do not simply dissipate. They are deposited onto surfaces and absorbed by them. People like me cannot enter some stores, because items we buy will have absorbed so much fragrance they can trigger coughing or intoxication in our own homes.

As a consumer, I want full disclosure of the ingredients of any fragrance dispensed into any publicly accessible space, and ventilation of any such space so the substances don't accumulate.
Roseville, California, US

From Nic Brough
I have been vaguely aware of the way smells affect me for a long time. I am struck by how wrong your list of smell associations is – or how it differs from mine. You say melon is associated worldwide with "happiness and youth"; for me it's lethargy. Lavender is "masculine and stimulating" – except that it evokes weakness for me, and femininity for a lot of people I know.

I am glad that I don't fit the generalisations. That gives me an extra line of defence against the marketeers – I'm truly sick of people trying to make me want stuff that I do not need.

But it worries me that some companies might start impregnating their products with smells. What if I buy a games

console and then find that it smells of lemon, which I find draining and depressing and to my girlfriend is nauseating and revolting? What if I go back to the shop and say "I want my money back because this smells bad"?
Wellingborough, Northamptonshire, UK

Monkeys' memory

From Alex Gore
You quote Robert Hampton as saying "there is nothing an animal can do to tell us about the quality of its private experience" (16 December 2006, p 28). He has shown that the rhesus monkeys he works with are aware of the difference between knowing a thing for certain and being unsure: they can do something as complex as deciding how much of a potential reward to stake on their response to a memory test.

Would it therefore be possible to add a stage to the experiment to find out whether they evaluate their own performance? Might they not be able to judge, at the end of the experiment, how well they performed – perhaps using another reward incentive?

They may be able to remember, for example, how long it took them to "win" their prize, and be able to communicate this; in doing so, they would be relaying their feelings about "their private experience".
Oswestry, Shropshire, UK

Unstable tables

From Andrew Cox
Your article on unstable tables (23/30 December 2006, p 38) will come as no surprise to anyone who studied mathematics at Exeter College, University of Oxford, under Dermot Roaf.

This was one of the "interesting problems" he set to first-year undergraduates each year: he had been setting the same problem for many years before I encountered it in 1996. The proof was exactly the same as the thought experiment in the article.
St Albans, Hertfordshire, UK

From Charles Sawyer
Like many theoretical scientists, André Martin perhaps lacks broad experience when he claims that any wobbling square table with equal legs can be made steady by rotation. I have such a table on our veranda, which wobbles no matter how it is rotated. Our veranda has uneven paving slabs with abrupt edges: his proof applies only if the ground surface is continuously differentiable (no steps) around the circle of rotation.
Byron Bay, New South Wales, Australia

SEE OUR WEBSITE FOR LETTERS ON:

- Face blindness
- Black hole turf war

● *The editor writes:*
To be fair to mathematicians, Burkard Polster and his colleagues do point out in their paper that the ground has to be continuous for their proof to work (www.arxiv.org/abs/math/0511490).

Paradoxical design

From David Prichard
Your editorial "It's still about religion" leaves me somewhat bemused (16 December 2006, p 5). Not because of its advocacy of "good science" over the intelligent design movement,

but because of the individuals it refers to whose zealotry requires they play a game that might be called "I'm the king of the (intellectual) castle".

In order to appear to have some mystical superiority, they contradict the bleeding obvious. To suggest that the complexity of existence is proof of intelligent design is a non sequitur.

Clearly, the opposite is true. Had some super intelligence designed everything, it would have been far simpler. It can be explained logically only by random (even chaotic) evolutionary events – unless, of course, the designer wasn't all that intelligent.
Geraldton, Western Australia

Design's purposes

From Ray Merewether
Douglas Axe of the Biologic Institute is far from the first to believe that bacteria had intelligent designers (16 December 2006, p 8). In the 17th century, New England settlers took it as a sign of divine providence that the Native Americans were dying of various diseases. Mark Twain in his *Letters from the Earth* similarly attributes a lot of bacterial misery to an intelligent designer.
La Jolla, California, US

Widdershins winds

From Martin Pettinger
Feedback muses how, in the absence of an analogue clock, the concept of clockwise and anticlockwise can be expressed (9 December 2006). We could use the nautical terms "veering" and "backing". Veering occurs when the direction from which the wind comes changes in a clockwise direction – for instance from the east to the south – and backing is the reverse.
Herstmonceux, East Sussex, UK

From Steve Fankuchen
Several years ago I visited a maths class at one of America's top private high schools and asked them what they thought the 1949 movie *Twelve O'Clock High* was about: was it probably about smoking pot in the cafeteria during lunch break? All either agreed, or said they had no idea.

I then explained to them that it was about aerial combat and that the title was a method of location entirely contingent on an understanding of analogue clocks. Conversion to digital clocks would do more than delete certain "facts": it would eliminate a way of viewing the world – an intellectual impoverishment.
Alameda, California, US

Server service

From Bart Holland
We are told that distributing 10 megabytes of information uses the energy equivalent of burning 900 grams of coal (16 December 2006, p 24). It would be interesting to calculate the energy consumption necessary to bring us the same amount of information in the form of, say, old-fashioned photographs – taking into account the production of the paper, the chemicals, transporting them, processing the photographic film, posting the pictures to friends via mail trucks, and so forth.

Are there significant economies of scale when producing certain kinds of material that is viewed only on the web rather than in the form of very numerous copies of large printed reference volumes? Certainly, web servers concentrate energy demand in one place and time, but it is not at all obvious whether more or less energy is used overall in a society where photographic and reference materials are held on servers rather than as hard copies.
New York, US

From Colin May
If a large part of the power used by these data centres is used to keep them cool, why not put them somewhere cool to start with: northern Alaska, Iceland or on top of a mountain, for instance? Who knows or cares where the web's servers actually are? These areas often have interesting alternative sources of power, too.
Zurich, Switzerland

Compulsory free will

From Tim Sprod
Forget free will, says Jim Haigh (23/30 December 2006, p 26). If it is so easy, he ought to be able to rewrite his letter to remove any assumption of free will from it. He tells us that "facing up to the fact that we lack free will seems to be so difficult." If he is right, then it is either compulsory (for people like him), or impossible; each of us has been determined either to reject free will or to accept it.

His letter is littered with other appeals: for us to choose to "make better progress", to "consider", to "live as if" and "to remember". Each of these are exhortations to make certain choices.

While determinists cannot do without the language of free will, I will continue to believe that the free will versus determinism debate remains a live one.
Taroona, Tasmania, Australia

Colour by number

From Dennis Fregger
I enjoyed your festive, light-hearted holiday issue – until I found the statement "Robotic art dates back to 1973" (23/30 December 2006, p 60). Back in 1963 my aunt, Joan Shogren, collaborated with Jim Larson in the engineering department at San Jose State College in California.

The computer filled in a grid at random, except as constrained by "rules of art" entered on punched cards, specifying colour, colour harmony, rhythm and composition. There were no colour printers in those days, so students and faculty were invited to colour in the resulting pictures.
Aptos, California, US

Price control

From Derek Bolton
Your reference to the "time riots" in England in 1752 could leave the impression that the rioters thought they were losing 11 days of their lives (23/30 December 2006, p 40). Maybe some thought that, but most were upset with good reason. Rents were paid quarterly, and the landlords still expected a full quarter's rent. No price watchdogs back then.
Birchgrove, New South Wales, Australia

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Letters to the Editor, New Scientist, 84 Theobald's Road, London WC1X 8NS
Fax: +44 (0) 20 7611 1280
Email: NS.letters@rbi.co.uk

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TALL, DARK AND DISHONEST

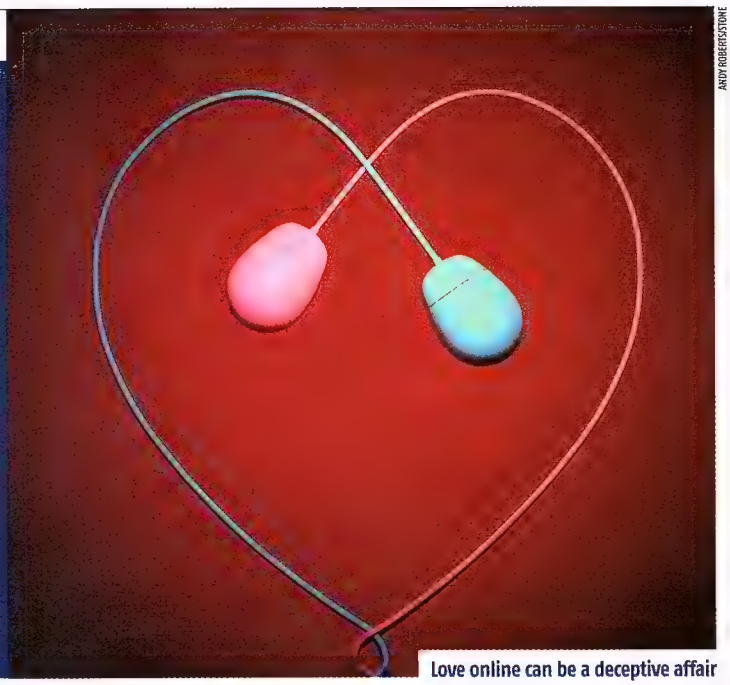
DATING sites, where users are free to shed pounds, up salaries and shave off years to impress prospective mates, seem like the perfect place to lie. Now a study that compared online profiles with real life has found that most daters do fib, but only in moderation.

"People were lying strategically. They told small lies that improved how they looked, but not so large that they would get busted if the daters met," says Jeff Hancock of Cornell University in Ithaca, New York. His team weighed and measured 40 male and 40 female New York City daters, noted the age on their driver's licences and compared the results with their online profiles.

Nearly 9 out of 10 participants lied at least once, with weight the most lied-about trait and age the least. There were also gender differences: every woman who lied about her weight said she was lighter than she was, while most men who lied about height made themselves taller. The heavier the women were, and the shorter the men, the more likely they were to tell fibs.

But while lies were frequent, the vast majority were unlikely to be uncovered in face-to-face meetings. The average difference between a profile and the reality was a mere 6 pounds in weight, one-third of an inch in height and just 5 months in age.

It seems that online dating sites get their bad rap from a few really big lies, which are most likely to get talked about. The worst whoppers in Hancock's survey were 3 inches in height, 35 pounds in weight and 11 years in age. "The big ones are much more memorable," he says.



ANDY ROBERTS/STONE

Love online can be a deceptive affair

Carbon tax turns into a health risk

BRITISH efforts to reduce global warming are good news for the climate but may need to carry a health warning.

In 2001 the UK began taxing vehicles according to their carbon dioxide emissions. Because diesel cars emit 20 per cent less CO_2 than petrol-powered vehicles, by 2005 diesel ownership had increased by 21 per cent. The downside of diesels is that they emit more particulates, which can cause respiratory and heart problems, so Hadi Dowlatabadi and Eric Mazzi at the University of British Columbia in Vancouver, Canada, studied the effect of the policy on air quality in the UK.

They estimate that the switch to diesel will reduce total CO_2 emissions between 2001 and 2020 by up to 7 megatonnes, but raise particulates by 12 kilotonnes, causing 90 extra deaths each year.

24

hours: the time it takes a robotic builder developed at the University of Southern California to build a two-storey house

SOURCE: THE SUNDAY TIMES, LONDON

Infrared can test for fresh frying

HOW fresh is the cooking oil in that deep fryer? An infrared device for the kitchen could give the answer quickly and easily.

Reused oil degrades into more than 400 different chemicals, which not only taste sour but can lead to stomach ulcers, cause DNA mutations and inhibit enzymes. To avoid using oil that is past its best, restaurants and manufacturers currently watch for telltale colour changes and replace oil regularly. Chemical tests are more precise but are also costly and time-consuming.

Now researchers at the University of Nebraska-Lincoln have found that fresh and degraded soybean oil absorb infrared light of different frequencies. "Our goal is a portable unit that could be used at the local McDonald's or Burger King within several years," says study author Randy Wehling.

MY NEXT PHONE MUST HAVE...

Some features offered by Apple's iPhone are low on existing cellphone users' wish lists

SOURCE: FORRESTER RESEARCH

GIZMO

Can't find a socket to charge your phone from? No problem, just get on your bike. Motorola's "kinetic charger", unveiled last week at the Consumer Electronics Show in Las Vegas, Nevada, can be attached to almost any bicycle. Electricity is generated when the rear wheel spins a dynamo, and a voltage regulator ensures a steady flow of power to the battery. Aimed at the developing world, the device is being tested in India.

Dental X-rays may soon be a front-line defence against thinning bones. Software developed at the University of Manchester in the UK analyses routine dental X-rays for signs of osteoporosis, based on the density of the jawbone. The software was able to flag more than half of women with the condition. Standard screening is expensive, so many women are not diagnosed until they break a bone.

"At a lot of airports, you can pull your car up to the plane"

Greg Johnson, chief executive of OneSky.com, which allows passengers to charter private jets online. Sales have doubled in the past six months as wealthy travellers become increasingly willing to pay extra to avoid security queues and competition for overhead baggage space (*The New York Times*, 15 January)

Start of the hologram wars?

One holographic disc will hold as much information as 300 DVDs. The problem is there are two types of them

DUNCAN GRAHAM-ROWE

AS THE war rages over what format will make up the next generation of DVDs, signs of an impending battle over their successors are already in the air.

A new type of disc that promises to cram in up to 300 times as much data as today's DVDs is poised to hit the market, and a similar, rival disc whose data is recorded and read differently is to be released within a few years.

The new discs use a holographic technique to store data in three dimensions. At first they will be used by businesses and governments to back up their vast archives, but in a few years they could hit the consumer market, with one disc able to store multiple high-definition movies. "We expect holographic storage to be really huge," says Mukul Krishna, an analyst with Frost and Sullivan based in San Antonio, Texas, who specialises in digital media.

Because two different ways of recording to and reading the discs are emerging, the new standard could result in a second DVD war, like the one now taking place between rival high-definition formats HD DVD and Blu-ray. "Whenever you have an emerging technology there is always a danger of this happening," says Krishna.

Holographic storage was first proposed over 40 years ago by Pieter van Heerden of Polaroid Research Labs in Cambridge, Massachusetts, but a suitable material for the discs proved elusive. Now two companies have come up with discs made of light-sensitive polymers that they say are up to the job. InPhase Technologies in Longmont, Colorado, is expected to release its disc within the next few months, while a product from DCE Aprilis in Maynard, Massachusetts, will be a few years in the making.

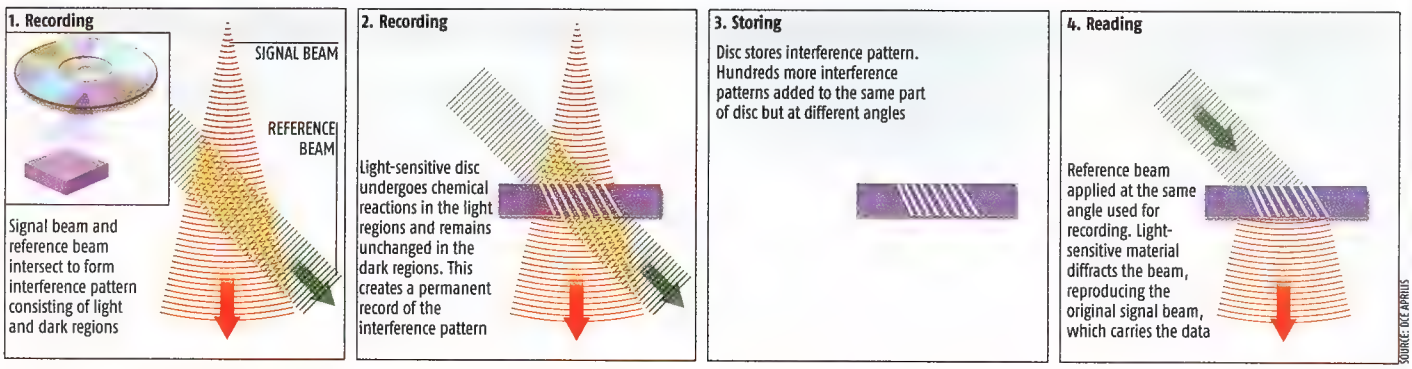
At first InPhase's discs will be capable of storing 300 gigabytes of data – that's 12 times as much as a single-sided Blu-ray disc and 60 times the capacity of a standard DVD. Within a few years this is expected to ramp up to a colossal 1.6 terabytes – around 300 times more than an ordinary DVD. DCE Aprilis is aiming for similar capacity with its discs.

Such high storage density is possible because, unlike conventional DVDs, which use reflective bumps on their surface to store data, holographic discs embed data throughout their thickness. Like holograms, in which multiple images are stored at the same point to create the illusion of a 3D object, holographic storage records "pages" of 1s and 0s in the same space. The result is that hundreds of pages can be stored in one microscopic area.

Although the two types of disc use different light-sensitive polymers, they rely on the same principles of holographic storage (see Diagram). Digital data to be stored is converted into a series of black and white pixels on a transparent LCD "page" inside the disc drive. Each pixel represents either a 1 or a 0 and each page holds around 1 million pixels. A laser beam is passed through the page, creating a "signal" beam with a pattern of light and dark patches that corresponds to the page. A set of mirrors inside the drive then directs a second "reference" beam to the disc's surface, where it combines with the signal beam to create an interference pattern with a new arrangement of light and dark patches. The disc's photosensitive polymer then stores the pattern. It does this by joining up small monomer molecules interspersed within it to form longer chains in the


ALAMY

RECORDING IN THREE DIMENSIONS



Why store in two dimensions when you can do it in three?

regions hit by light patches, while the monomers remain disconnected in the dark regions.

Crucially, the angle at which the light from the interference pattern hits the polymer ensures that only some of the monomers at that point react to the light. This enables hundreds of pages to be written at the same point on the DVD's surface: each one is stored by shining the interference pattern onto the polymer at a slightly different angle.

A page is read by shining a reference beam onto the point at the exact angle that was used when the data was encoded. The beam that diffracts off the material will contain a pattern of light and dark patches that exactly reproduces the original signal beam. This is then translated back into a series of 1s and 0s.

Here, though, is where the similarities between the InPhase and DCE Aprilis technologies end. DCE Aprilis's discs can read and record discs very fast, in excess of a gigabyte per second, according to David Waldman, the company's chief scientist.

In contrast, InPhase's drives currently read at a maximum speed of 20 megabytes per second and record even more slowly.

This is because the compounds used by the two companies react to light in different ways. InPhase's polymer undergoes a process called "free-radical polymerisation", whereas the Aprilis polymer uses "cationic ring-opening polymerisation". Free-radical polymerisation requires light of a higher intensity than the ring-opening version, so the interference pattern must be shone on InPhase's polymer for longer to result in a recording, slowing the process down.

"We expect holographic storage to be huge. It could hit the consumer market in a few years"

What InPhase lacks in speed it makes up for in having a market-ready product. Its Tapestry 300R drives are already being shipped to several electronics companies, with a wide-scale launch scheduled for the second half of the year, says Liz Murphy of InPhase.

At 13 centimetres across the discs are slightly larger than a conventional DVD, and are encased in a protective cartridge. The drives have a 15-centimetre-square front and are 60 centimetres deep.

Costing $18,000 for the drive and another $180 for each disc cartridge, the InPhase equipment is unlikely to appeal to even the most memory-hungry home user. Instead, InPhase's first customers will be organisations that generate hundreds of gigabytes of data each day, such as government agencies, broadcasters, medical organisations and IT companies. "If you're generating that much data it can become unmanageable," says Murphy (See "Where to put all that data").

The polymer developed by DCE Aprilis is more likely to find its way directly to consumers. The company's partners, which include Sony, are aiming to eventually produce a mass-market replacement for Blu-ray and HD DVD. "Every single large consumer electronics company in Japan and South Korea is testing and evaluating our materials," says Waldman. InPhase says it plans to roll out consumer applications for holographic memory at a later stage.

Having such huge storage capabilities for entertainment may seem like overkill – after all, do we really need to be able to store multiple high-definition movies on a single DVD? But as image resolutions become ever higher, even Blu-ray and HD DVD are likely to feel the strain.

If both companies do move into the high-definition movie market as planned, it could create a headache for consumers. Like the Blu-ray and HD DVD formats, which both store high-definition video but are read using different hardware, a rivalry could emerge between the DCE Aprilis and InPhase technologies.

InPhase records and reads discs by shining a series of lasers at the same point at hundreds of different angles then moving on to the next point. This means the disc does not spin, but instead constantly stops and starts. Because the DCE Aprilis disc can be read faster, it spins continuously. This difference in approach will require different readers, potentially forcing consumers once again to choose between one standard and another.

One problem that remains is that holographic discs are not yet rewritable. Both companies are working on a solution, but given the vast gulf between the way the two systems record it seems likely that there will be an even greater difference between the way they can be rewritten. ●

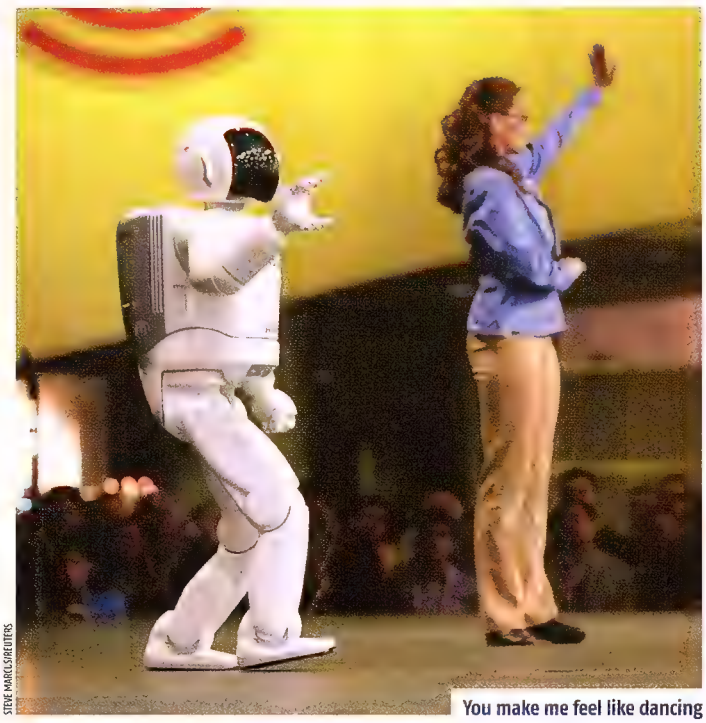
WHERE TO PUT ALL THAT DATA

While holographic storage might one day replace Blu-ray or HD DVD as the medium for high-definition video recordings, its first application will be backing up the hundreds of gigabytes of data generated by government agencies, broadcasters, medical firms and IT companies every day.

At the moment the only method that is fast and cheap enough to back up this quantity of data is good old-fashioned magnetic tape, says Immo Gathman of the German jukebox manufacturer DSM. But even modern tape formats typically only last about 10 years and have to be played periodically to avoid degradation. To take advantage of holographic storage technology, DSM has signed a deal with InPhase Technologies of Longmont, Colorado.

Ironically, another problem with existing methods for mass digital storage is that, like their paper counterparts, how much you can store often comes down to how many square metres of space you have. Just last month Google and NASA announced a deal that involves the internet giant taking over part of the role of managing the huge volumes of data the space agency recovers. It has been reported that Google will be given nearly 100,000 square metres of warehouse storage space. All this points to a dire need to develop much denser digital storage mediums, says Liz Murphy of InPhase.

It takes a certain special feeling to click with robots



STEVE MARCUS/REUTERS

You make me feel like dancing

NO RELATIONSHIP is easy. If humans are ever to truly relate to robotic companions and teachers, we'll have to ensure they trigger a specific type of brain activity that we get from interacting with real people. So say researchers who have shown that a robotic hand can be made to activate the brain machinery partly responsible for empathy with other humans.

Robots are increasingly entering our lives as companions, educational aides and medical assistants. But till now no one had probed whether the human brain responds to these automatons in the same way that it does to human helpers.

To find out, Lindsay Oberman and colleagues at the University of California, San Diego, decided to see what effect robots have on mirror neurons (DOI: 10.1016/j.neucom.2006.02.024). These are brain cells that fire not only when an individual performs an action, but also when they see someone else perform that action. "Evidence suggests these neurons are needed for mimicry, learning, language acquisition and empathy," says Oberman.

The researchers recorded the brain activity of volunteers while they were shown videos of a metallic, five-fingered robotic hand opening and closing and grasping an object. They also recorded the activity while a video of random static was shown.

The team found that videos of the hand triggered activity in an area at the front of the brain containing mirror neurons, while the static did not. This indicates that humans make sense of the robotic action in the same way that they would if it had been carried out by a human.

"Robots that stimulate mirror neurons could also be used unfairly"

The discovery could trigger a new approach to robot design. In the same way that the Turing test is about whether a robot can pass itself off as human in a written conversation, brain scans of human observers could form the basis for a "neural Turing test" that would measure a robot's ability to engage our brains. "If we want humanoid robots to teach or have other social functions, we need them to trigger mirror neurons," says Oberman.

The next step is to work out which robot characteristics best trigger mirror neurons. "I would like to see tests on a spectrum of different humanoid robots that might tell us what it is that can trigger this neural system, and to what degree," says Kerstin Dautenhahn, who studies human-robot interaction at the University of Hertfordshire in Hatfield, UK.

However, she warns, mirror-neuron stimulating robots could also be used to unfairly influence thoughts and feelings. "It is not always desirable to try and affect people in this way. We will need to be careful." **Tom Simonite** ●

Dose of crystals could make moon base self-sufficient

WHEN NASA sets up its permanent base on the moon, how will the colonists keep themselves going? How will they get oxygen to breathe, and where will they find building materials, not to mention silicon for all the solar panels they will need?

Easy, says Geoffrey Landis of NASA's Glenn Research Center in Cleveland, Ohio. All these materials can be made from moon dust.

Landis's plan is to use just one chemical shipped from Earth – potassium fluoride, in crystal form – to extract a range of useful materials from the "regolith" that makes up the moon's surface.

In 2005 NASA launched the Moon Regolith Oxygen challenge to spark research into extracting oxygen from this lunar soil (*New Scientist*, 28 May 2005, p 6). Landis sees the fine, grey powder as having much more potential than that, however.

Regolith locks up silicon, iron, aluminium and at least seven other metals as oxides. To liberate them, Landis plans to use two forms of solar power. First, solar panels will generate electricity to break up potassium fluoride via electrolysis, releasing fluorine gas. Then the gas will be pumped over regolith that has been heated to more than 600 °C by a mirrored solar energy concentrator, a device that has been successfully tested on the International Space Station.

The gas converts iron, silicon and aluminium oxides into fluoride salts, which can then be electrolysed to recover the silicon and metals.

"Oxygen, building materials and silicon can all be made from moon dust"

The reactions also liberate oxygen, which could be used for life support, and releases the fluorine in the salts as gas once more.

As potassium fluoride is not found on the moon, Landis's scheme does not give moon dwellers complete self-sufficiency. If the fluorine gas produced could be fed back into the regolith reaction chamber, at least the shipment from Earth would only need to be a one-off. This might prove difficult, according to materials scientist Alex Freundlich of the University of Houston, Texas. If it can be made to work, though, it would also prevent lunar pollution by waste fluorine: "The environmental impact would be pretty small," says Landis. Paul Marks ●

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Spinning Einstein

If we want a theory of everything, we might have to break a few rules, says **Amanda Gefter**

IT'S not every day that respectable scientists challenge Einstein. But that's what Nobel prizewinner Sheldon Glashow and his colleague Andrew Cohen, both of Boston University in Massachusetts, have dared to do. They believe it is time to rewrite the rules of Einstein's special theory of relativity, our best description of the nature of space and time for over a century.

They call their theory very special relativity, or VSR. If Glashow and Cohen are right, it could tell us something profound about the fabric of the universe. It could solve a troubling mystery in particle physics. And it might get us a little closer to solving the problem at the top of most theorists' wish-lists: how to find a theory of everything.

The crucial evidence supporting Glashow and Cohen's theory may be right in front of your nose. Or, more accurately, passing right through it. For as you read this sentence, trillions of tiny particles called neutrinos are sailing through your body, imperceptible and undisturbed by the atoms that give you substance. Experiments conducted throughout the past decade have shown that neutrinos have mass, even though our best theory of matter claims that they ought to be massless. While formulating their new theory, Glashow and Cohen realised that a neutrino's mass may actually be a clue to an irregularity in space-time itself.

Einstein's theory of special relativity revolutionised our conceptions of space and time by exposing the symmetries that underlie the reality we see around us. Symmetries are those aspects of the world that do not change when we view them from different perspectives. No matter how we rotate a circle, for instance, its geometry always looks the same, so we can say that a circle has 360-degree rotational symmetry.

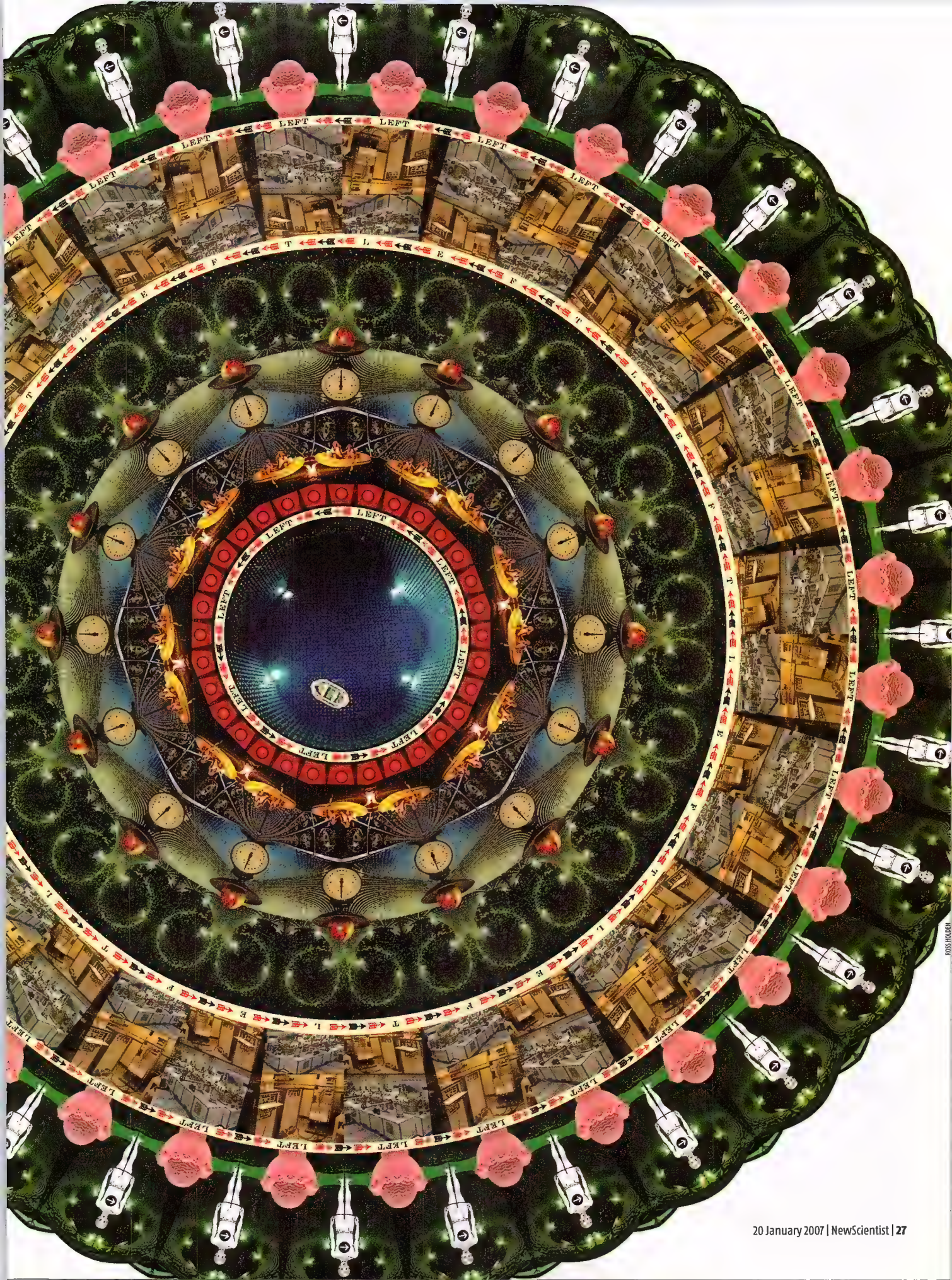
Einstein began with two basic postulates from which the special theory of relativity spilled forth. The first is that the speed of light is always the same regardless of how the light source is moving; the second, that the laws of physics are the same for all observers who are moving at a constant speed.

For these two postulates to hold, space-time must have certain symmetries which, taken together, form the so-called Lorentz symmetry group, which concerns rotations and changes in velocity. If you were conducting a physics experiment, and your laboratory flipped upside down or began moving at a different speed, the fundamental laws of nature would not change, thanks to Lorentz symmetry.

Add to the Lorentz group the symmetry of space-time translations – meaning that you could move the laboratory, say, 50 metres to the west or forward three years in time without changing the results of your experiment – and you have the full set of symmetries encompassed by special relativity. You also have the full weirdness that it implies: the speed of light remains the same no matter how fast the light source is moving, time slows and distances contract at near-light speeds, energy and mass are interchangeable, and events that appear simultaneous to one observer do not to another.

Today, however, many physicists wonder whether Lorentz symmetry is a true ▶

"Very special relativity could tell us that space-time treats some directions differently"



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symmetry, or if in fact it might be broken at extremely small distances or enormously high energies. They are motivated by the search for a theory of everything, something that can unite the seemingly incompatible theories of quantum mechanics – which describes the behaviour of subatomic particles – and general relativity, Einstein's extension of the theory to include gravity.

One-way universe

Various approaches to creating such a theory of everything have all suggested that Lorentz symmetry might be broken at the so-called Planck scale, around 10^{-35} metres, where both quantum mechanics and gravity come into play. Two such theories, string theory and loop quantum gravity, hint towards broken Lorentz symmetry. Another approach called non-commutative geometry explicitly calls for it. "If Lorentz violations are discovered, they would provide an experimental handle on the underlying unified theory combining gravity and quantum physics – a handle that is sorely lacking to date," says Alan Kostelecky, a physicist at Indiana University in Bloomington.

Dozens of experiments looking for signs of broken Lorentz symmetry have been carried out. Not one has found any. That doesn't mean Lorentz symmetry is safe and sound, though. It just means that experiments have not been sensitive enough so far, or that physicists are looking in the wrong place.

Until now, physicists have searched for violations of Lorentz symmetry by picking away at well-tested consequences of special relativity such as the slowing of time or the constancy of the speed of light, which has led to experiments with light streaming in different directions or clocks flying at daredevil speeds. Glashow and Cohen, however, have found a way to break Lorentz symmetry without disturbing any of those cherished relativistic effects. They modified the special theory of relativity to reduce the amount of symmetry and so formulated very special relativity.

In this new theory, Lorentz symmetry is not fully intact, yet the key effects of special relativity remain unaffected. "People are shocked," says Cohen. "I don't believe anyone ever contemplated that there could be Lorentz violation while one of the basic ideas of special relativity, the constancy of the speed of light, could still be preserved."

What is lost in VSR, however, is the full rotational symmetry of space-time. "Not all directions are the same in VSR," says Glashow. "There's a preferred direction in space." Here on Earth, for instance, the preferred direction is down. That's because the mass of the planet breaks the symmetry of the surrounding space-time and gravity selects a unique direction. But that's merely circumstantial – the underlying laws of physics see every direction as equal. Or so we thought. Cohen and Glashow are suggesting that maybe, even in the absence of a planet or anything else, space-time itself treats some directions differently from others.

According to VSR, the break in rotational symmetry should be extremely small and therefore unnoticeable at everyday scales. That's why, if such asymmetry exists, it has gone undetected for so long. "Rotational invariance is one of the additional postulates included in special relativity," Cohen says, "because people just have this intrinsic prejudice for it. What we said is, if you give up rotational invariance, there are these other possibilities." In other words, accept that space-time is even more counter-intuitive than we thought, and you might get a little closer to a theory of everything.

Although we have tested rotational invariance to a very high degree of accuracy, there is still wiggle room. "What's surprising is that if you give it up, these other possibilities nevertheless look very nearly rotationally invariant – just not exactly," Cohen says.

So at how small a scale would we find VSR's Lorentz violation? The answer lies with the neutrinos that are sailing through your body. Those ethereal little ghosts are hardly of this world, interacting with matter only through gravity, which barely notices them, and the so-called weak force, which exerts itself only in the cores of atomic nuclei. They are the least understood particles in the otherwise explicit framework of the standard model, our best description of the building blocks of matter and the forces that glue them together. Now, however, new explanations of the strange qualities of neutrinos are paving the way toward a deeper comprehension of the universe than the standard model offers.

"Evidence for very special relativity may be right in front of your nose. Or, more accurately, passing right through it"

Spinning neutrinos

It has been eight years since physicists first found conclusive evidence that neutrinos have mass, contrary to the predictions of the standard model. The 1998 discovery was made in Super-Kamiokande, a neutrino observatory located 1 kilometre below ground in a mine in Kamiokande, Japan. Neutrinos come in three distinct types or "flavours", but the Super-K experiment found that they were morphing from one flavour into another as they fell from the sky. It was as if you ordered a scoop of chocolate ice cream that transformed into strawberry on its way toward your lips and settled into vanilla upon your tongue.

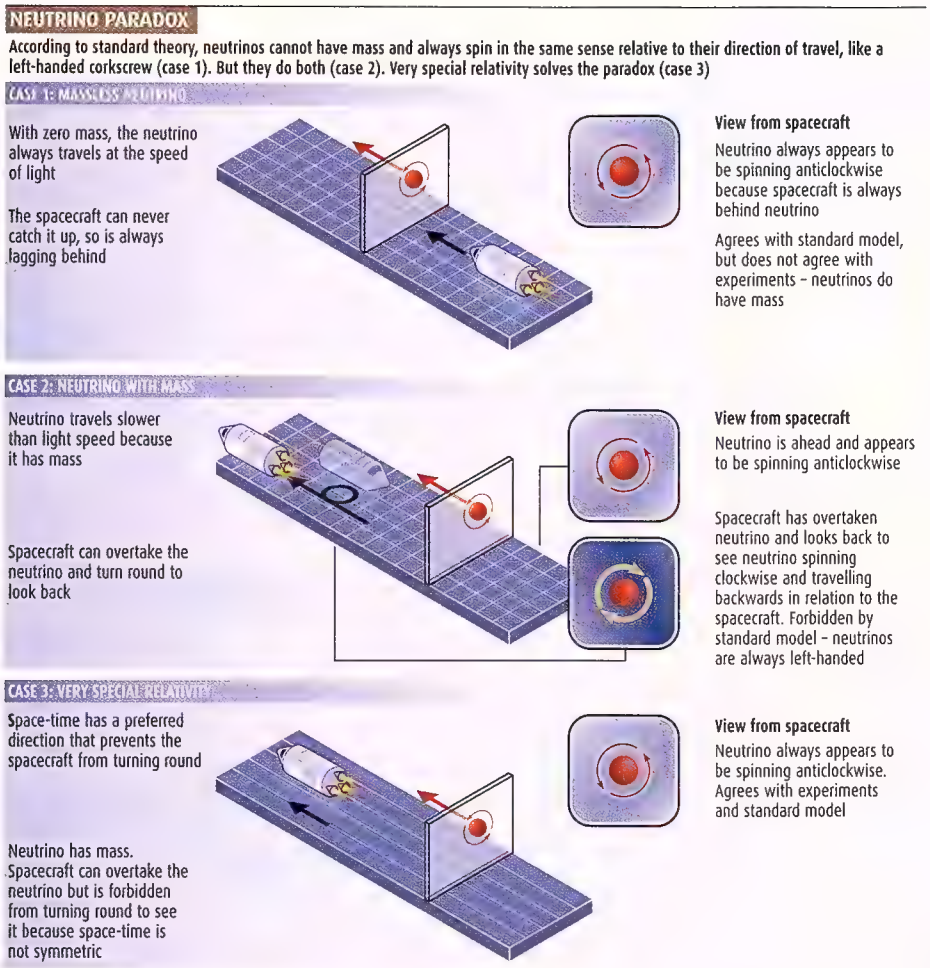
The laws of quantum mechanics dictate that only particles with mass can change from one flavour to another. And so neutrinos, it seemed, must have a mass, albeit an incredibly tiny amount: a neutrino seems to be 100,000 million times lighter than a proton. The discovery was the first glimpse of physics beyond the standard model.

Physicists, however, still have no idea how neutrinos can have mass. It is the way that neutrinos spin that is so puzzling. Researchers have observed that some particles are "ambidextrous" – they can spin either to the right or to the left – while others are strictly one-handed.

Every neutrino ever observed has been left-handed. Yet only massless particles can be one-handed, and here's why. Imagine you are watching a particle travelling along and spinning to the left. You start running and soon you are running faster than the particle. As you sprint ahead of it, you look over your shoulder and see the particle spinning the other way round (see Graphic).

In other words, for any particle that spins to the left, there is some reference frame from which a faster-moving observer can look back and see the particle spinning to the right, making it ambidextrous. That is, unless the particle is moving at the speed of light, the fastest possible speed, in which case there's no way that any observer can outrun it. And only massless particles can move at light speed.

If neutrinos are always observed to be spinning to the left, then no observer must be able to outrun them, which means they must be travelling at light speed and they must be



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massless. Yet the Super-K results clearly showed that neutrinos have mass. How can a particle be both left-handed and massive?

Glashow and Cohen's theory can solve the paradox. It just so happens that the scale of VSR's Lorentz violation is right around the scale of the neutrino's tiny mass. "Suddenly we realised that within the context of very special relativity, neutrinos can acquire mass," says Glashow.

A left-handed neutrino with mass will appear right-handed if you run past it, turn around and look back at it. But that's exactly what VSR doesn't allow you to do. Although you can run faster than the neutrino, you can't turn back around to see it spinning the other way. Turning around is forbidden by VSR, because according to the theory, the rotational symmetry of space is broken, so the laws of physics forbid certain rotations. What emerges is an elegant explanation for what seemed like an impossible paradox. Neutrinos do move more slowly than the speed of light – on account of their mass – but no observer can ever see them spinning the other way. Neutrinos in a VSR universe can be exclusively left-handed and have mass at the same time.

True, other explanations have been proposed for the origin of neutrino mass. "They don't invoke something as dramatic as violating Lorentz invariance," says physicist Sean Carroll of the California Institute of Technology in Pasadena. One way is to invent a new kind of particle called a sterile neutrino (*New Scientist*, 17 June 2006, p 46), a much heavier kind of neutrino that is right-handed. The sterile neutrino is even more ghostly than its counterpart, interacting with matter through gravity alone, which would explain why no one has ever observed one and probably never will.

VSR, on the other hand, makes several clear predictions that can be tested in the near future. One is to watch the radioactive decay of tritium, a heavy isotope of hydrogen with two extra neutrons. As it decays, tritium spits out an electron and an antineutrino. Because of the law of conservation of momentum, measuring the momentum of the outgoing electron (which is far easier to pin down than an elusive antineutrino) provides a detailed profile of the momentum of the antineutrino, which in turn depends on its mass.

If VSR is correct, it should limit tritium's momentum as it coughs up antineutrinos. This would show up in a graph plotting the number of electrons versus energy. "You get a slightly different spectrum of the electrons coming out," says Cohen.

Predictive power

So far, tritium decay experiments have not seen any evidence of a neutrino's mass, let alone VSR. However, Cohen points out that they have not yet been done at the necessary sensitivity. A more sensitive experiment called KATRIN is being built at the Karlsruhe Research Centre in Germany. This might measure a neutrino's mass and possibly spot the first signs of Lorentz violation.

Another experiment involves looking at properties of electrons such as the magnetic dipole moment, a measure of the strength and direction of the electron's response to a magnetic field. "If space has a preferred direction, as VSR claims, it will influence the electron in a way that should show up as a very peculiar time-dependent effect," Cohen says.

Glashow and Cohen are trying to convince a Harvard colleague, Gerald Gabrielse, to look for the effect. Gabrielse's team recently measured the electron's magnetic moment in the most precise measure to date of the fine structure constant, a gauge of the strength of the electromagnetic interaction (*New Scientist*, 12 September 2006, p 40). Now Gabrielse has to determine whether it is possible to measure the electron's magnetic moment with enough sensitivity to look for the VSR effect. If it is, Glashow and Cohen's theory could be put to the test within a few years.

If VSR turns out to be right, it will mark a major turning point in physics not only for our understanding of how neutrinos get their mass, but also for our understanding of the very fabric of reality. "If they were to find experimental evidence of Lorentz violation, that certainly would be ground-breaking," says Carroll.

It would also be troublesome. "Most of the physics community would rather not believe that VSR is right, and with good reason," says Glashow. The reason is that even small deviations from special relativity translate into big problems for general relativity. "It's an unpleasant fact that anyone who thinks about violations of special relativity doesn't really know what to do to fix up general relativity," says Cohen. Solving one big mystery, it seems, may create an even bigger one. Those who challenge Einstein do so at their peril. ●

Further reading: "Very special relativity" by Andrew Cohen and Sheldon Glashow, *Physical Review Letters*, vol 97, p 021601

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Instant

gold

Volcanoes can be good for more than lava and ash

Look in the right place and you'll find deposits of the precious metal forming before your eyes. **Phil McKenna** goes prospecting

I WANT to strike it rich? Then listen up: there might be new gold in them there hills. Not just undiscovered gold, you understand, but brand new deposits. It seems the glistening metal that remains the ultimate symbol of wealth may be able to collect far faster than anyone thought possible. Giant deposits of the stuff could be laid down within a human lifetime, or even in a matter of days.

For as long as anyone has understood the basics of geology, it has been assumed that it takes millions of years for gold ore to be deposited. Now investigations of a mysterious mine at the centre of a volcano on Lihir Island in Papua New Guinea are changing all that. "Just when we thought we had a handle on how gold forms, the rapid formation at Lihir is turning everything we've known on its head," says Mark Hannington, an expert in economic geology at the University of Ottawa, Canada.

The discoveries are not only changing our understanding of the processes that lead to the formation of gold deposits, they could also transform the way prospectors search for their precious prize.

Gold is hard to find, of course; if it wasn't, it wouldn't be so valuable. Normally scattered through the Earth's crust at trace levels, it sometimes becomes concentrated in deposits containing myriad metallic specks, usually too small to be seen with the naked eye. A variety of mechanisms are involved in the formation of these deposits, everything from highly pressurised rocks oozing gold-rich fluid deep underground, to rivers leaving traces of gold residue on their banks.

The precious stuff can also be deposited by hot springs and other hydrothermal systems in which water from deep underground, heated by molten rock or magma, rises to the surface carrying dissolved gold with it. It is now estimated that one-fifth of all gold deposits in the world, including the one on Lihir Island, are formed this way.

Whatever the mechanism, everything seemed to point to the process being an extremely slow one. In the early 1990s Edwin McKee of the US Geological Survey used radiometric dating – a technique based on the rate of decay of isotopes into stable elements – to assess gold deposits in the Andes, and concluded that it took a million years or more for the deposits to form. Studies of other precious metals have since suggested they might form on shorter timescales, but overall the slow and steady theory of gold ore formation continued to hold sway.

TREASURE ISLAND

Lihir Island in Papua New Guinea is home to one of the world's largest gold mines

To create a gold deposit, three things must exist: a gold source, a means of transport and a trap. For hydrothermal systems, researchers figured out that magma was the likely source. As plumes of the molten rock start to cool and crystallise deep within the Earth's crust, they exude a layer of water-based fluid that rises towards the surface. It has long been known that this fluid is rich with dissolved minerals, including gold and sulphur volatiles, and since the 1970s this was thought to be the means of transport. However, the mechanism of the trap, which causes gold to precipitate out of this fluid as pure metal, remained a mystery.

The means of transport didn't quite fit either. Measurements of active hot springs that seemed likely sources of future gold deposits were not turning up enough dissolved gold. Concentrations were so low that it would take millions of years to form a substantial deposit – far longer than the molten rock underneath was thought to last.

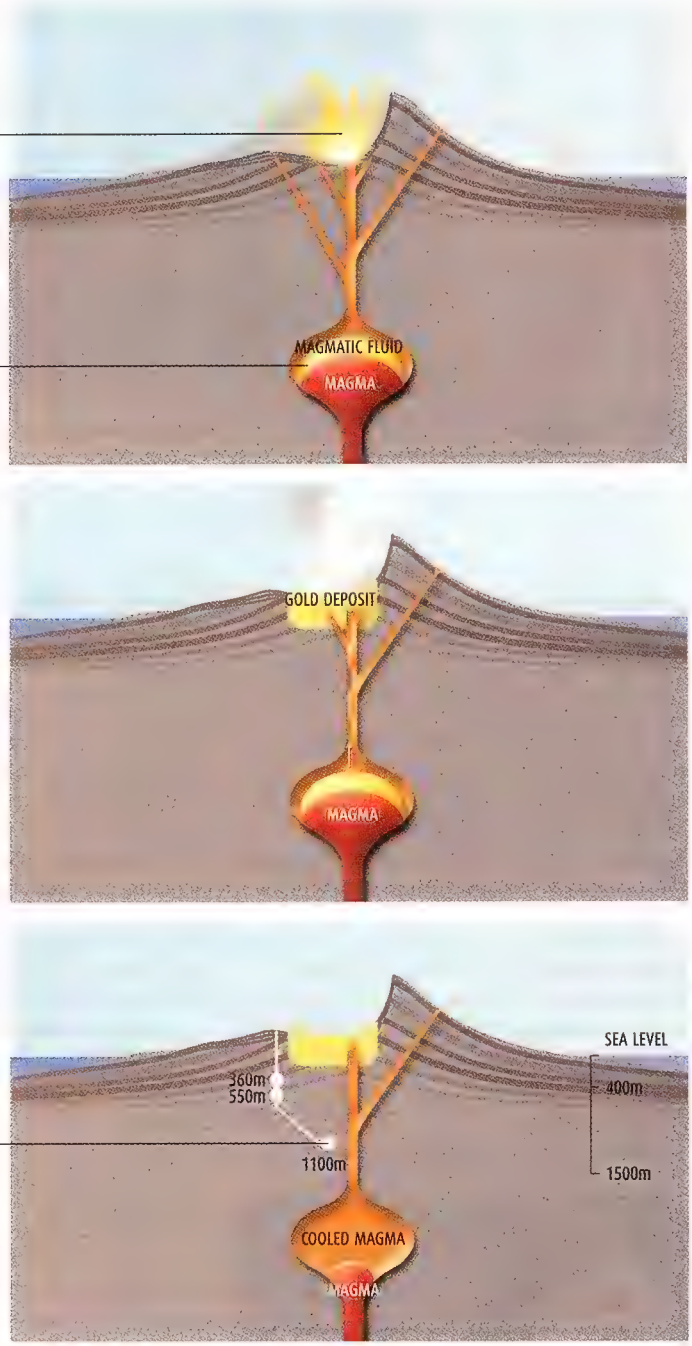
Then in 1985, Kevin Brown, a geochemist at the Wairakei Geothermal Research Centre in New Zealand, made a startling discovery. The steam that drove the plant's turbines was generated by allowing superheated, pressurised water from deep underground to expand through small holes in metal plates held at the surface. As some of the water evaporated it left behind a hard, greenish build-up around the hole in one such plate, and when Brown tested this he found it contained a surprisingly large amount of gold. "It blew us away when we actually found out what it was," says Brown, who is now an independent consultant.

He realised that the water everybody had been testing at hot springs had already lost ▶

JULES COWAN/IMAGE STATE AFP/GETTY

IT ONLY TAKES A FEW YEARS...

Measurements from a volcano on Lihir Island in Papua New Guinea show that a catastrophic event can cause a large gold deposit to form in thousands of years or even less – perhaps much, much less



SOURCE: JEFFREY HEDENQUIST, COLORADO SCHOOL OF MINES

the vast majority of its gold. As water and sulphur volatiles changed from liquid to steam near the surface, he reasoned, they left behind a residue of minerals, including gold, that had been dissolved in the fluid. If he was correct, he had found the missing link in how hydrothermal systems form gold deposits: the fluid was the means of transport, and the trap was a decrease in pressure that boiled off the sulphur, changing the properties of the solution and causing gold to precipitate out of the remaining water. Crucially, this also meant that deposits might form much faster than anyone had thought.

To find out for sure, he needed to obtain water samples from beneath a gold deposit where the hydrothermal system that had created it was still active. There was only one such place, the colossal Ladolam deposit on Lihir Island, one of the youngest and largest gold ore deposits in the world, containing more than 1000 tonnes of gold (see Diagram, left). There was just one problem: the fluid he needed to sample would be a good kilometre below the surface.

For 20 years, Brown worked on and off to collect the sample. His chance came after miners drilled a series of deep wells under the Ladolam deposit to reduce the temperature and pressure of steam trapped beneath the mine, for safety reasons. Their orientation posed a problem, however. Drilling for some wells began with a vertical shaft sunk at the perimeter of the deposit, which then changed direction to pass underneath it. To capture a sample, Brown needed to devise a container that could be lowered straight down, then crawl at an angle. Once in position, it had to fill with fluid, seal itself shut while deep underground, and return to the surface without leaking a drop of its precious cargo.

The sampler Brown eventually produced was a 2-metre-long titanium cylinder fitted with wheels that enabled the the device to roll downwards under the influence of gravity. Mounted on the side of the sampler near the top was a pair of hinged poles initially folded back against the side like an insect's wings. Once the device was lowered into position, a tug on a cable would raise the sampler to wedge the wings into the sides of the well. This triggered a mechanism that drove a sharp needle into a thin sheet of metal on top of the cylinder, making a hole 2 millimetres in diameter. The high-pressure well water would force its way in through a one-way valve, and remain trapped inside the sampler.

All the gold mined in history, 193,000 tonnes, would fit in a cube with sides 22 metres long

When Brown and geologist Stuart Simmons of the University of Auckland in New Zealand analysed the water, their idea was confirmed. The water contained 15 parts per billion of dissolved gold – a thousand times the highest concentration ever recorded in the surface waters of hydrothermal systems. The researchers calculated that, given the rate of flow of water in the Lihir system, 24 kilograms of gold are being added to the Ladolam deposit each year, and that the entire ore deposit could have formed in as little as 55,000 years (*Science*, vol 314, p 288).

Even this rapid rate of formation may be too conservative, according to calculations by

Geothermal power plants may allow us to harvest gold from underground water

J BERNDES/ABIZEFA/CORBIS

Riches of the Rand

Forty per cent of all gold mined during recorded history has come in the past 120 years from the Witwatersrand Basin in South Africa. No one really knows how "the Rand" got so much gold. One hypothesis is that prehistoric rivers carried the gold into a lake or seabed that shaped the current basin. In this scenario, the gold flowed in from the surrounding mountains over aeons and accumulated as sediment. Another hypothesis is that the gold arrived after the sediment was laid down.

A recent study by geologist John Chesley's team at the University of Arizona in Tucson using new radiometric dating techniques found the Rand's gold to be the same age as the sediment, about 3 billion years. That means the gold could not have formed after the sediment was deposited and therefore must have eroded from surrounding mountains.

But how did the gold get into the mountains in the first place? The researchers now think it initially formed via a hydrothermal system similar to that on Lihir Island, but they still have no idea how so much gold could have been deposited. "Geologists hate each other for life over their opinions on this stuff," says Stuart Simmons of the University of Auckland, New Zealand. "These are highly emotive debates that take on an almost religious fervour."

Christoph Heinrich of the Swiss Federal Institute of Technology in Zurich. Heinrich has spent more than a decade analysing microscopic samples of hydrothermal fluids trapped inside quartz crystals that formed several kilometres beneath the surface. Smashing the crystals liberates trace amounts of the fluid, and when Heinrich analysed this he found gold concentrations much greater than those at Lihir.

So he thinks the hydrothermal system investigated by Brown and Simmons may have passed its prime and could once have contained greater concentrations of gold. "We have found fluids that had a thousand times higher concentrations," Heinrich says of sites he has studied in Argentina, Indonesia, south-east Europe and the US. "If you spin the same argument that they are using with a thousand times higher concentrations, then the time it takes might have been a thousand times shorter – 50 or 60 years."

Perfect storm

How so? The Lihir deposit could have formed during a single cataclysmic event, Heinrich suggests. It is known that an eruption on Lihir about 400,000 years ago sent a quarter of the volcanic island tumbling into the sea. This collapse could have allowed the gold-rich fluid below what remained of the volcano to shoot to the surface and precipitate quickly into a concentrated deposit (see Diagram, opposite). "My best guess is it happened within 50 years, shortly after this collapse," Heinrich says.

Now we're talking – but could it have happened even faster? Greg Hall, former chief geologist and exploration manager for the Canadian gold-mining company Placer Dome, says it could. "My gut feeling looking at Lihir is that it formed in the same time it took Mount St Helens to blow up – a month, a day, maybe as short as 5 hours," Hall says. He believes there was a "perfect storm" of circumstances that came together to form the massive deposit. "You need a big reservoir of magma that is pregnant with gold-rich solution, but you also need a trigger that is fast, like the top of a volcano blowing off, so that you can release the solution instantaneously."

It wouldn't always be that fast. "I think you are going to find there is huge variation," McKee says. "Gold deposits can probably form anywhere from on the order of a million years to a matter of hours."

So where will the next gold rush occur? Rather than wait for nature to take its course, Simmons and Brown have been trying to use their results to engineer an artificial gold trap. In the 1990s, after Brown discovered gold precipitating in the geothermal plant, he built a couple of vessels that collected gold from water passing from high to low pressure in wells near another New Zealand plant. Each vessel, about the size and shape of an oil drum, contained a series of about 50 steel plates riddled with small holes. The holes allowed water to flow through the vessel while the plates provided a large surface area onto which gold could precipitate.

Disappointingly, the yield wasn't worth the effort. "It would cost NZ$3 million [US$2 million] to get half a million of gold," Brown says of the estimated annual cost and revenue, assuming it ran for 10 years. Much of the cost comes from building a vessel to withstand such high pressures. Other costs come from losses at the plant when the well has to be shut down to scrape the gold off the metal plates. "Every hour that the power station is offline you are just haemorrhaging money," he says.

Prospects might be improving, however. The price of gold has nearly doubled since Brown's first collector was built. And in September last year, the US Department of Energy flew Brown to Tucson, Arizona, to speak about the possibilities of artificial traps at a conference on mineral extraction from hydrothermal waters. Along with Simmons, Brown is now trying to secure funding to test new vessel designs. One possibility is a two-vessel system in which the vessels could be alternately switched in and out to avoid interrupting the plant's steam supply while the gold is harvested. Increasing the surface area of the plates and finding materials that speed up the deposition could also help.

"This is never going to be the next Lihir," Brown admits, "but it might be a profitable sideline for a power station. The hydrothermal system is already doing the mining for you. All you have to do is extract the gold." ●

Phil McKenna is a science journalist based in Boston

http://environment.newscientist.com

Hungry genes?

Diets tailored to your genetic profile are being sold as the ultimate in healthy eating. But does the science add up, asks **Bijal Trivedi**

IT SOUNDS like the ultimate in personalised medicine: a tailor-made diet that controls your weight, optimises your health and reduces your risk of heart disease, cancer and diabetes. All you have to do to get one is hand over a couple of hundred dollars, take a simple genetic test, and wait for a personalised nutrition plan based on your genes to drop through your door.

Diet plans like this are widely available from private clinics, over the internet and, in the US, even in some supermarkets. Advocates claim they take the uncertainty out of grocery shopping and provide a guaranteed route to long-term health and fitness. Critics say the tests are at best misleading and at worst potentially harmful. I was simply curious. With my family history of heart disease, I wanted to know whether a diet tailored to my DNA could help me override my genes.

In theory, yes. All other things being equal, genetics is the reason why one person can eat a poor diet without serious health repercussions while in another person the same diet leads to high blood pressure, cancer or heart disease. This is the basis of nutrigenomics – the science of how the chemicals in food alter the regulation of genes and proteins, and how variations in certain genes might predispose people to troublesome gene-nutrient interactions and ultimately disease. Nutrigenomics is a relatively new science with genuine promise, but it has yet to yield many results of practical value. Even so, no sooner had nutrigenomics got off the ground than eager biotech companies began mining the results of newly published papers and translating them into over-the-counter tests. So does the science support such tests?

Each person has around 25,000 genes, many of which have several common variants. Some are linked to an increased risk of disease. The tests look at a handful of such genes to identify which variants the individual carries. If they have "bad" variants, the company offers advice on how nutritional and lifestyle changes could help counteract genetic flaws.

In 2001 the UK-based company Sciona broke new ground with the first such "nutrigenetic" testing service to provide personalised dietary and lifestyle advice. Nutrigenetics is the application of nutrigenomics – which looks at the genome in general – to the individual. However, the test soon drew criticism from the UK's Human Genetics Commission, and prompted the HGC's 2003 report "Genes Direct", which assessed genetics-testing kits sold directly to the public. The watchdog group GeneWatch UK also criticised the tests and called on major UK retailers to boycott the products.

The UK retail market soon collapsed, and Sciona focused on marketing the product to private health clinics, dieticians and nutritionists instead. The company relocated to Boulder, Colorado, in 2005, and began selling tests in the US via websites and genetic-testing companies; last year it sold about 18,000. Other companies sprang up offering the Sciona test, or something similar, for $100 to $1000.

The nutrigenetics industry has recently come under renewed fire, this time in the US. An investigation conducted by the US Government Accountability Office in July suggested that the type of nutrigenetic testing offered by four companies – Sciona, Genelex, Market America and Suracell – "misled consumers by making predictions that are medically unproven and so ambiguous that they do not provide meaningful information". The GAO report also criticised some companies for selling supplements supposedly tailored to a customer's genetic needs. These "nutraceuticals" cost anywhere

from $1200 to $1800 per year, yet according to the report they differed little from multivitamins available at the local pharmacy.

Despite this, I wanted to know whether I had gene variants that could increase my risk of broken bones, heart disease or cancer, and was intrigued by what the nutritional advice might be. Sciona provided me with its "Cellf" test, which is the most widely sold test of its kind, available at many online drugstores and shopping sites and sold by two of the four companies scrutinised by the GAO investigation. It looks at 19 genes that the company believes provide insights into heart and bone health, the body's antioxidant and detoxification ability, plus insulin sensitivity and inflammatory response. Market America also sells a test of the same genes, but under another name. I swabbed the inside of my cheek, completed a food and lifestyle questionnaire, and slipped both in the mail.

The good and the bad

Six weeks later I received my results. First, the good news. For the two genes related to antioxidant ability, which help destroy DNA-damaging free radicals, I have no "bad" variants. Of the three genes involved in detoxification I have versions that efficiently rid my body of noxious compounds.

Now the not-so-good news. My number one priority, according to the report, is bone health. The test screened for a total of seven variants, spread over four genes, each linked to bone problems. I tested positive for four potentially damaging variants. Two hinder absorption of calcium and vitamin D – ingredients critical for bone building – and the other two disrupt the process of dissolving old bone and creating new bone. It sounds to me like I'm a prime candidate for osteoporosis.

Sciona's advice: increase daily intake of vitamin D to 20 micrograms and omega-3 fatty acids to 3 grams, and exercise for 45 to 60 minutes at least five times per week. I get a pat on the back for getting enough calcium, my moderate caffeine consumption, and for my healthy body mass index.

Next: heart health. The test reveals that I have variants in several genes that alter my body's ability to metabolise B vitamins – like folic acid, B_6 and B_{12}. These vitamins are important for maintaining low levels of homocysteine – high levels of which are a risk factor for cardiovascular disease. Also, my variants of the inflammatory-response genes can lead to "reactions that are too strong or inappropriate in their timing", according to Sciona, which could damage my cardiovascular system. I also have potentially problematic variants in genes that metabolise cholesterol and triglycerides, and another

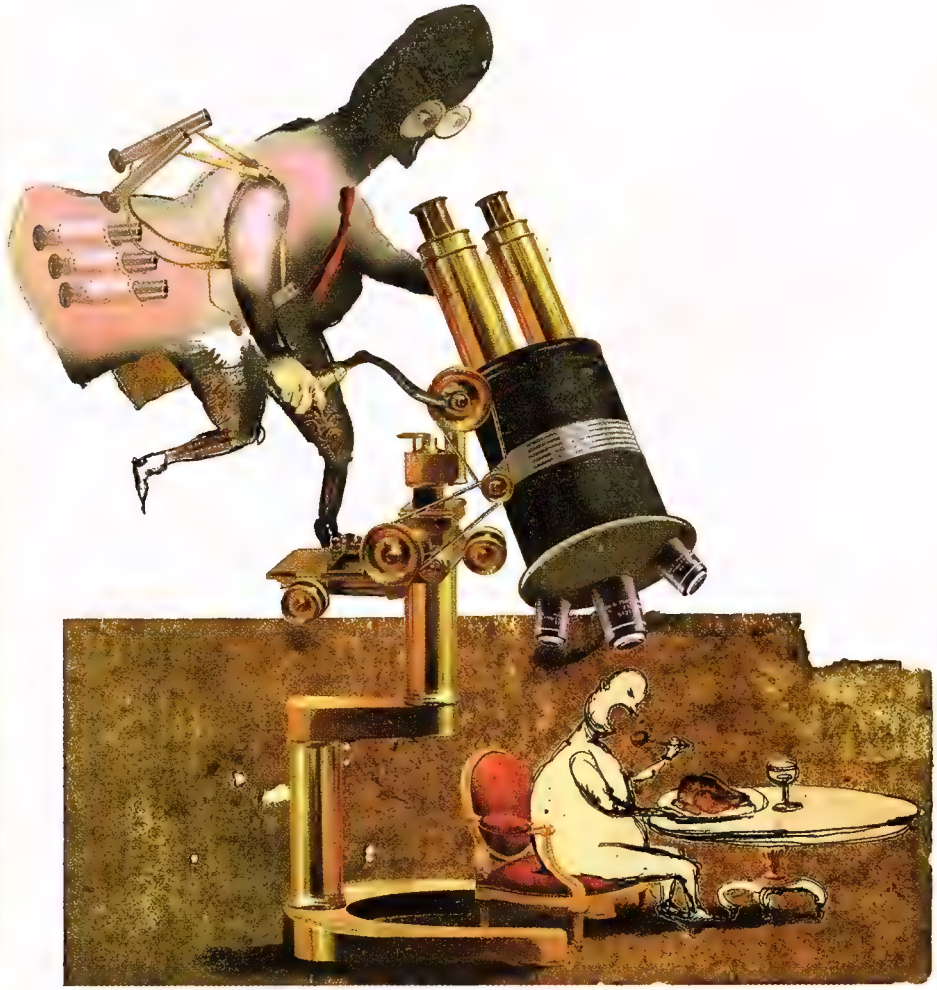
Out of control?

In the European Union, the US, Australia and Canada genetic testing is coming under increasing scrutiny, and governments are making efforts to standardise regulations. However, nutrigenetic tests are considered "lifestyle" tests, largely because they do not make clinical claims.

"The EU considers most genetic tests low-risk and thus exempt from independent pre-market review. This means that as long as the company can honestly state the technical accuracy of the test, the sale of the test and the advice offered is unregulated," says Stuart Hogarth, a research associate at the University of Cambridge who specialises in policy issues with genetic testing. In Canada and Australia there are even fewer controls. Nutrigenetic tests are reviewed for neither analytical nor clinical accuracy.

In the US, the majority of tests being offered are "home brews": companies receive genetic samples directly from physicians or consumers, do the analyses, and then issue a report. Historically, the Food and Drug Administration has not regulated these tests. "That means you don't have an evaluation of the clinical validity of the test," says Kathy Hudson, director of the Washington-based Genetics and Public Policy Center.

Jose Ordovas, director of the Nutrition and Genomics Laboratory at Tufts University in Boston, supports the idea of personalised nutrition but is concerned that the current batch of nutrigenetics tests is too much, too soon. Without regulation, he cautions, jumping the gun could wipe out public support and damage the reputation of the entire field. "We are very, very early in the game," he says.



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in a gene that alters blood flow, which can adversely affect "tightening of your blood vessels". Nowhere does the report say I'm at increased risk of a heart attack, but reading between the lines I feel like a time bomb.

The final segment of Sciona's report covers insulin sensitivity. In four of the five genes tested, I have variants that make my fat cells less efficient at removing sugar from my blood and storing it in the cells. That means insulin resistance, which has been linked not only to type 2 diabetes but high blood pressure and heart disease as well.

While all this sounds quite alarming Sciona's advice on how to deal with these risks seems comparatively mundane: eat more foods rich in B-vitamins and antioxidants like vitamins A, C and E, and increase the amount of omega-3 fatty acids; decrease my glycaemic load (how much sugar I pour into my blood) and eat more fibre and whole grains; cut down saturated fats and cholesterol; exercise more. The advice hardly seems personalised but Rosalynn Gill-Garrison, co-founder and chief scientific officer of Sciona, assures me the intake goals are calculated based on my particular genetic make-up.

Paranoid that my bones are disintegrating and my arteries narrowing I seek a second opinion. Jose Ordovas, director of the Nutrition and Genomics Laboratory at Tufts University in Boston, provides reassurance. "The genetic component [of a complex disease] is split among 10, 20, 50, 100 genes or more, and you are being tested for one," he says. "Remember, you can go wrong with one of your genes but you may be blessed with another set of genes that compensate."

Robert Nussbaum, chief of the medical genetics division of the Institute for Human Genetics at the University of California, San Francisco, puts it even more bluntly. "I don't think it is information worth having... I wouldn't trust any of it," he says. "Testing negative [for certain variants] doesn't mean that you are not going to develop these diseases; testing positive doesn't mean that you will. If I was asked by a patient what would I recommend based on this test, bottom line: eat right."

So if feeding my genes is as simple as eating healthily and laying off the fat and sugar, what good has it done me to find out about specific variations? According to critics of such tests, not much. Nussbaum says that the science behind the tests is often far from conclusive – and may be based on single studies that have never been replicated.

One example is California-based Consumer Genetics's "caffeine metabolism test", which went on the market in November. The test is based on a paper published in March 2006 in *The Journal of the American Medical Association* (*JAMA*). It reported that depending on what version you carry of the gene *CYP1A2*, which codes for the caffeine-metabolising enzyme cytochrome P450 1A2, you are either a "rapid" or "slow" caffeine metaboliser. According to the *JAMA* report, higher caffeine intake is associated with increased risk of heart attack only in people with slow caffeine metabolism. Within weeks of publication, Consumer Genetics announced on its website that it would offer a caffeine metabolism test and give results within three days.

Hannia Campos, a nutritionist at the Harvard School of Public Health and a co-author of the *JAMA* paper, says that she was shocked when she discovered the findings had been translated into a genetic test. "I couldn't believe it. I thought it was a joke." She says the findings need to replicated and confirmed before they are used to guide people.

What's more, the tests lack clinical validity, says Nussbaum. That is, the gene variations that the companies are testing have a pretty low "positive predictive value", meaning that even among people who carry a "bad" variant, only a small percentage actually go on to develop the disease. "None of these genes is going to kill you," says Ordovas. "It might put you at 5 or 10 per cent higher risk than somebody [without the variant], but that's it."

Proof of the pudding

In comparison, a family history of heart disease, especially the early-onset form, has been shown to increase risk 100 to 500 per cent, says Howard Levy, a physician and medical geneticist at Johns Hopkins University in Baltimore, Maryland. "Family history is the biggest thing missing from what this company has to offer." he adds.

More to the point, says Levy, even when the associations between genes and disease are fairly robust, it is far from clear whether increasing intake of specific nutrients will lower the risk. Take, for example, variants of the *MTHFR* gene and heart disease. Of the genes tested in the Cellf test, all the researchers I contacted agreed that this had the strongest association; individuals carrying the variation known as C677T had higher levels of homocysteine, which is associated with an increased risk of heart disease.

It is also known that folic acid and vitamins B_6 and B_{12} lower homocysteine levels. Sciona and Genelex both advise people to consume more B vitamins if they test positive for potentially problematic variations in the *MTHFR* gene. But two studies published in *The New England Journal of Medicine* in April reported that, although supplements of B vitamins could lower homocysteine levels, this did not reduce the risk of heart attacks in patients with vascular disease.

In fact, says Philip Wood, director of the genomics division at the University of Alabama at Birmingham, no studies have demonstrated that any nutritional supplementation would actually overcome a genetic variation and reduce the risk of a complex disease. "That would require clinical trials... and those studies haven't been done."

Howard Coleman, CEO of Genelex, disagrees. "There needs to be a symmetry between the level of proof and the risk associated with something," he says. "The clinical-trial standard is the standard you need to have if you are going to give somebody a dangerous drug. Remember, this is just a harmless test. [Dietary interventions] are helpful but can do no harm."

"What would I recommend based on this test? Bottom line: eat right"

While he acknowledges that the conclusions are "not medically proven in the sense that there's been clinical trials done", he disputes the GAO's notion that the advice is worthless. "An expert in this area... may say it is too soon or that it is not worth the money but they won't say it is worthless. We are at the early stages of this – we are playing Pong and transitioning to Pac-Man."

Sciona's Gill-Garrison is also confident about the tests. "If we claimed we were going to make you live 100 years or prevent the development of a particular disease, I would agree with them, but on the other hand if we are providing personalised info to help you control cholesterol levels because of particular sensitivities you have based on your genetics – absolutely there is enough information."

Genelex connected me with Carolyn Katzin, a Los Angeles-based certified nutrition specialist, for a personal consultation and interpretation of my genetic results. Genelex usually charges an additional couple of hundred dollars for this service, a total of $525 for the test plus consultation.

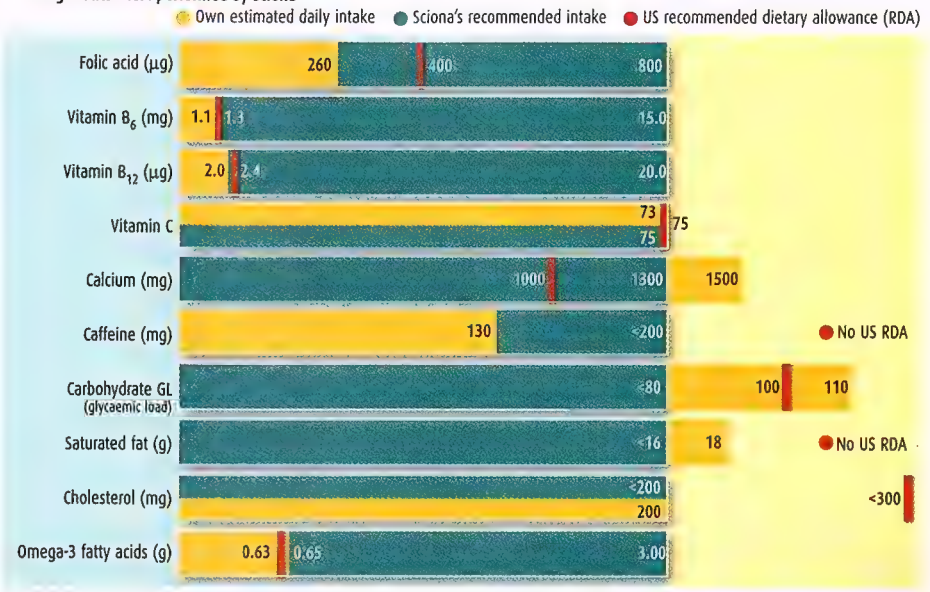
Katzin's analysis differed from Sciona's by ignoring the food questionnaires, which she says are not accurate indicators of nutrient intake, and instead asked about family history before focusing on my genes. She offered much the same nutritional advice as Sciona, however – eat more of this, less of that, take a good multivitamin, add specific supplements, and "be careful with salt and avoid too many packaged or processed foods". Her knowledge of my family history, though, did lead her to suggest, after seeing my mixed bag of gene variants, that I check my levels of homocysteine, HDL and LDL cholesterol, triglyceride and C-reactive protein – all of which have been linked to cardiovascular disease risk – the next time I get a physical.

One of the major criticisms about nutrigenetics testing is that it may induce complacency in people who find they have "good" genes and panic in those who find theirs are "bad". The information is certainly difficult to ignore when it's there in black and white. But good genes or bad, discussing family history with a physician and taking a few blood tests will probably give you a similar or more accurate snapshot of your current health – and without the hefty price tag. That is exactly what I'm going to do. Now if I can just get an appointment... ●

Bijal Trivedi is a freelance science writer based in Washington DC

FEEDING MY GENES

Author's current intake of key nutrients compared with the US dietary recommendations and Sciona's advice, based on the results of a "neutrigenetics" test performed by Sciona



The K fix

Best known as a club drug, ketamine seems somehow able to jolt people out of severe depression. **Maia Szalavitz** investigates

"FOR MANY, it was a huge, obvious effect," says psychiatrist John Krystal. "One of the patients said, 'Don't give me those old medications, I want this again'."

Krystal, a professor at Yale University, is talking about the time he gave seven severely depressed patients ketamine, a mind-blowing drug developed as an anaesthetic but better known as a club drug. It was a long shot, but the results were astonishing. Though most of the patients found the ketamine experience itself unpleasant, once it wore off they had a far better feeling: the disabling and suicidal depression they had lived with for years had vanished.

Krystal's pioneering experiment happened in the late 1990s, but now researchers at the US National Institute of Mental Health (NIMH) in Bethesda, Maryland, have repeated the study and the results have got psychiatrists, neuroscientists and drug companies buzzing. An antidepressant that acts in hours rather than weeks would transform the treatment of depression, make a lot of money and change the way we understand the disease.

It's not just depression. Other studies suggest that ketamine might act with similar speed to help addiction, post-traumatic stress disorder (PTSD) and certain chronic pain conditions. Ketamine, researchers increasingly believe, may be a "reset button" for brains stuck in dysfunctional ruts.

Depression affects over 120 million people worldwide, making it the fourth largest contributor to the global burden of disease, according to the World Health Organization. At some point in their lives 13 per cent of Americans experience major depression, and globally 850,000 depressed people kill themselves every year.

Treatments are available, but they are slow to kick in and help only about 80 per cent of patients. Drugs such as Prozac and Lustral take between 10 days and six weeks to work; even electroconvulsive therapy (ECT), the fastest-acting treatment, takes at least a week. For 70 per cent of patients the first thing they try does not help. This means that many spend months trying different drugs before finding one that works for them – if they ever do.

That's why the ketamine results are creating such a stir. "This is a hot topic and people are very interested in it," says Lisa Monteggia, a neuroscientist specialising in depression at the University of Texas Southwestern Medical Center in Dallas. "The implications are huge." "It's very intriguing," agrees Lee Schechter, director of preclinical depression and anxiety research at Wyeth Pharmaceuticals in Princeton, New Jersey. Research on rapid antidepressants is now "an area of focus within the industry," he says.

The possibility that ketamine could lift depression was first mooted in the late 1990s, when Krystal and his colleagues were studying the drug as a way of understanding schizophrenia. Ketamine is classed as a "dissociative" because it produces feelings of disconnection from one's self and reality which are similar to some of the symptoms of schizophrenia; very high doses elicit complete depersonalisation and profoundly altered perception. Some have described this "k-hole" as similar to an out-of-body experience.

In the course of his work, Krystal had come across case reports from the 1950s and 1960s suggesting that depressed tuberculosis patients given a TB drug with pharmacological similarities to ketamine sometimes reported rapid release from their depression. He also found research showing that some existing antidepressants worked in a similar way.

Krystal's group put two and two together and decided to give ketamine a try as an ▶

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antidepressant. They recruited seven patients with treatment-resistant depression – defined as disease so severe that two or more medications have failed – and gave each of them an infusion of either ketamine or a placebo. A week later the subjects were "crossed over" so those who had received ketamine got the placebo and vice versa.

The results, published in 2000, were dramatic: within three days of receiving the ketamine all seven had improved, some profoundly, and they remained so for at least a week. The placebo had little effect (*Biological Psychiatry*, vol 47, p 351).

Shortly after that experiment, Krystal's colleague Dennis Charney left Yale for NIMH, taking the depression work with him. Last year he and Carlos Zarate, head of the mood disorders research unit, published the results of a larger follow-up study (*Archives of General Psychiatry*, vol 63, p 856).

Zarate's results were not quite as dramatic as Krystal's but were impressive nevertheless. His team recruited 17 people who on average had failed to get relief from six different drugs; four had even tried ECT, the treatment of last resort. Of the 17, 12 experienced a strong antidepressant response within hours of receiving ketamine, and for six patients the response lasted a week or more. As Zarate describes it, the subjects reported that their depression "lifted".

Zarate's results make all the difference, Krystal says. "Replication is everything. One exciting finding is a footnote but a replication makes it much more interesting, particularly by a different group. It has opened up discussion about rapid-acting antidepressants."

As both researchers point out, the volunteers didn't feel better because they were on a "high" similar to a cocaine buzz, which some depressed people use to lift their mood. "I would really contrast ketamine's effects on depression to those of cocaine," says Krystal. "The hallmark of drugs of abuse is a transient euphoria followed by persistent dysphoria – the cocaine crash. Ketamine is fundamentally different. There may be brief euphoric effects but when those symptoms go away, instead of being dysphoric or hung-over, what we and Dr Zarate's group saw was remarkable."

Still, ketamine has a long way to go before it can prove itself as an antidepressant. Both Krystal and Zarate restricted their patients to a single infusion, so it remains unclear whether a second dose of ketamine would work; equally unclear is whether ketamine would carry on relieving depression if given regularly, or whether this would even be practical given the side effects and cost.

One intriguing possibility is that a single dose of ketamine might allow regular drugs to succeed where they have previously failed. After the trial, Zarate found that some of the volunteers responded better than expected to conventional antidepressants, suggesting that the ketamine had somehow cleared the way, or sensitised them to drugs they were previously immune to. Zarate's group is planning a second, larger trial, and he says there is "more interest than I could have imagined" in additional work.

Even if ketamine doesn't make it as an antidepressant in its own right, the trials make it clear that depression medications do not have to take weeks or months to start working – an excruciating time lag that can push patients already on the brink of suicide over the edge. The ketamine research suggests that it should be possible to develop other fast-acting antidepressants, as well as hinting that today's theories of depression are not the whole story.

"Ketamine somehow reboots the brain"

Brain shrinkage

The existence of the therapeutic time lag has long been seen as a critical part of an elegant theory of depression that has been coming together since the late 1990s. Before then, researchers saw depression as a result of a deficit in certain neurotransmitters, principally serotonin. That made sense when it turned out that drugs like Prozac, which raise serotonin levels, were effective antidepressants. However, medications that worked on other neurotransmitters often also worked and, most damagingly to this idea, even though drugs could change levels of their target neurotransmitter within hours, they still took weeks to elevate mood.

Enter the neurotrophic theory. Put simply, the idea is that extreme or prolonged stress can cause depression by damaging nerve cells in certain brain regions, particularly an area important for storing and consolidating memories called the hippocampus. Brain scans and autopsies find shrinkage in this area in depressed people.

There's even research suggesting exactly how stress could cause this damage. Under stress, the brain releases an excess of the excitatory neurotransmitter glutamate. Too much glutamate can damage or kill cells, a process known as excitotoxicity. The hippocampus is especially vulnerable.

So stress leads to nerve damage, which causes depression. Further evidence is that every drug known to help lift depression also seems to induce higher levels of peptides that encourage nerve growth, most notably BDNF, or brain-derived neurotrophic factor. This helps to repair injured cells and promotes the growth of new ones. Nerves take time to grow, though, hence the delay.

Ketamine, of course, isn't likely to be busy restoring or replacing damaged cells, so what is it doing? No one really knows, but there are some plausible ideas. Ketamine is known to work by blocking a glutamate receptor called the NMDA receptor, preventing glutamate from transmitting its message across the synapse. Faulty NMDA receptor function has recently been implicated in depression, and repeated doses of conventional antidepressants have been shown to slowly correct it in animal models. Perhaps ketamine does the job in one fell swoop. "One way of thinking about it is that the ketamine has reset the normal activity that was disturbed," says Monteggia. In other words, briefly blocking NMDA receptors with ketamine somehow reboots the system.

The reboot idea isn't the only possibility. Ketamine activates another glutamate receptor, known as AMPA, and this has been found to have antidepressant effects in animals; what is more, forthcoming research from NIMH appears to show that preventing AMPA activation blocks ketamine's antidepressant effect. Another possibility is that ketamine works by directly increasing levels of BDNF. That wouldn't account for ketamine's rapid action, of course, but it's possible that BDNF may act not just as a growth factor but as a neurotransmitter too. Some animal studies have found that infusing BDNF into the brain reverses depression-like symptoms in three days

Whatever the mechanism, most researchers in the area think it should be possible to produce a drug that selectively blocks the NMDA receptor without inducing ketamine-like hallucinations. In fact, at least one such drug already exists, developed by Merck and as yet unnamed. "In initial studies, we didn't see depersonalisation and psychosis-like side effects," says Husseini Manji of NIMH, which is collaborating with

Merck to determine whether the compound works as an antidepressant.

Krystal isn't sure such drugs will do the trick. It is possible, he says, that ketamine's bizarre effects are an integral part of the process and not side effects that should be eliminated.

Other approaches to rapidly reversing depression are also attracting attention. Researchers at NIMH recently published a pilot study showing that scopolamine, which is normally used to treat motion sickness, appears to lift depression in three days (*Archives of General Psychiatry*, vol 63, p 1121).

Ketamine research – particularly the idea that manipulating NMDA receptors might reboot aberrant brain activity – also holds promise for chronic pain, addiction and post-traumatic stress disorder. While these are diverse conditions, researchers believe they may all be connected with abnormalities of the NMDA receptor, which is involved with learning and memory, or "neuroplasticity". In each case the brain may have learned a harmful pattern of responses "too well" and now cannot break free from it.

Addiction and pain

"The idea is that the [glutamate system] is very important to many forms of neuroplasticity. Many people are very interested in the idea of manipulating it so that acute stress doesn't produce chronic problems," says Krystal.

Take addiction, for example. Researchers know that one NMDA blocker, the herbal hallucinogen ibogaine, can help heroin addicts break their habit. Ketamine is a more potent NMDA blocker and seems to have similar effects in rat and human studies. Meanwhile, a group led by Evgeny Krupitsky at the Pavlov State Medical University of Saint Petersburg in Russia is studying ketamine as a treatment for alcoholism. Another illness in which memories seem to trap the brain in a dysfunctional rut is post-traumatic stress disorder. Ketamine may help, though nobody has tried it yet.

The drug may also be useful for treating some forms of chronic pain. Over the past few years neurologist Robert Schwartzman of Drexel University College of Medicine in Philadelphia and colleagues at the University of Tübingen in Germany have used ketamine to treat 41 patients with reflex sympathetic dystrophy (RSD). This is a rare, disabling pain disorder in which ordinary sensations such as touch, warmth and coolness are perceived as painful and minor knocks are agonising. RSD is associated with nerve injuries, after accidents or surgery, for example.

Schwartzman's methods are not for the faint-hearted. He gives RSD sufferers doses of ketamine high enough to put them in a coma for five days, accompanied by anti-anxiety medications to reduce the nightmare of the k-hole. But for many, the results are worth it. In 14 cases out of 41, according to Schwartzman, patients were completely cured. "We haven't cured the original injury," he says, "but we have cured the RSD or kept it in remission. The RSD pain is gone."

"No one ever cured it before," he adds. "In 40 years, I have never seen anything like it. These are people who were disabled and in horrible pain. Most were completely incapacitated. They go back to work, back to school, and are doing everything they used to do. Most are on no medications at all. I have taken morphine pumps out of people. You turn off the pain and reset the whole system."

Results with six of these people have been presented at a meeting, and other peer-reviewed research by Schwartzman has shown that ketamine can help RSD pain, but the ketamine coma approach has yet to be subjected to a proper trial. The German group continues to offer the procedure and US researchers, including Schwartzman, are also collaborating with a research group in Mexico.

Realistically, with these complex and chronic conditions, it is unlikely that a one-time treatment will be a complete cure: with addiction, depression and RSD, it is already clear that many people either do not respond or relapse at some point after ketamine therapy. But understanding how the NMDA and glutamate systems drive memory and create responses that are resistant to change could offer insights well beyond these conditions in which the brain has got stuck in a rut and needs a reboot. Ketamine's mind-altering properties may be far more useful than any clubber ever imagined. ●

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"In 40 years, I have never seen anything like it"

Maia Szalavitz is a writer based in New York City

Over the border

The internet recently passed a milestone: its billionth user ventured online. Yet the idea that we all work and play on a common global internet is merely an illusion. In reality, the web is becoming ever more fragmented, and international borders are increasingly visible online. More and more web pages are appearing in languages other than English. China has more than 130 million internet users and is starting to play by its own rules. Soon to follow are the Middle East, India, Russia and Brazil. Is the technology that we thought was uniting us really dividing us? Global blogging expert **Ethan Zuckerman** is concerned, but optimistic. **Gregory T. Huang** spoke with Zuckerman about the future of the global web and its next billion users.

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Profile

Ethan Zuckerman is a research fellow at the Berkman Center for Internet and Society at Harvard Law School in Cambridge, Massachusetts. An expert on weblogs and technology in the developing world, he co-founded Tripod, one of the earliest dotcoms, which was bought by Lycos in 1999. In 2000, he co-founded Geekcorps, a non-profit volunteer service to run technology projects in emerging nations. He currently helps run Global Voices, an online community of blogs from around the world (www.globalvoicesonline.org). You can read his personal blog at: www.ethanzuckerman.com/blog/

What's happening to the internet as it becomes truly global?

There is what I call the problem of the internets. We are very used to this notion that we live on one common internet. It might be slower in some places than others, but it's basically the same thing. That's not true any more, and it hasn't been true for a while. It stopped being true when the French and Germans started censoring neo-Nazi sites, and even more so when China put up an effective firewall to block certain websites. The robust internet industry in China is not oriented to the whole world as a market, but really just to China as a market. That sort of thing is changing how the internet as we know it works.

How are its demographics changing?

If you look at how many people are on the internet, we've just surpassed one billion. It's mostly North America, China, western Europe, South Korea, Japan and little bits elsewhere. The next billion are most likely calling from Brazil, Russia, India, South Africa and more from China – the developing-world powers. A few other African countries are also coming up fast. This is going to be really different. Once you start getting lots of people who speak Chinese on the internet, for instance, they don't necessarily need to learn English to interact. They won't post in English.

Hasn't this happened already?

We've already seen this a bit with Orkut, the social networking service. Brazilians took to Orkut in a big way, and they ended up taking it over in a way that worried other users. American users started saying, "Stop using Portuguese, this is an English service, an American service!" In fact, it's a profoundly non-English service – it was designed to let people cross international lines. Orkut was the name of the Turkish programmer who put it together. But that is the assumption we have built into the first billion internet users: that as people get to the point in economic development where they can join the internet, surely they'll know English. Surely they'll have the same basic cultural values and such.

Clearly that's not the case.

The next billion users will not look like that. They will be a very different group of people, less willing to speak a common language. They will have different cultures and sensitivities. Things like the Danish cartoon scandal will become routine. People will fight about things. We're not ready for it, but it's happening.

How are all these people going to get online?

The next billion will get online using smart phones with screens and keyboards, lower-cost PCs and increasingly cheap laptops. But to get the third and fourth billion, it's going to get a little crazy. That's where programmes like Nicholas Negroponte's "one laptop per child" come into play. When you

"The next billion users will have different cultures and sensitivities. We're not ready"

Ethan Zuckerman is working to bridge increasing cultural divides as the internet grows

get to the point where 3 billion people are online, including all the world's schoolkids creating content and hacking your sites, blogging, sharing photos and music, that will be a really interesting brave new world.

You've made an effort to bring together voices from different countries and cultures on the internet.
In 2004 I co-founded Global Voices at the Berkman Center with Rebecca MacKinnon. Global Voices is an aggregator of global blogs, a newswire of great posts from around the world. It is put together by regional editors who are following what's going on in their communities. This is the only way to keep track of global blogs. We make it available for English-speaking audiences. Mainstream media miss stories about some of the most important parts of the world. There's either little or no coverage, or the wrong types of coverage. By highlighting what people are actually thinking and talking about on their blogs, we are able to provide a counterweight to the mainstream media.

How many people are reading these posts?
We had 1.1 million in early 2006. The main page is getting hard to read because there's so much stuff. You can subscribe to countries, regions or topics. For us, the value in this is the editors. As information explodes around the web, we need editors to feature the good stuff. For instance, we have an editor for Latin America who emails a list of the five or six best blogs of the day. If you're an interested citizen, you probably want that email.

The internet is global, but doesn't most of the technology come out of the west?
Most of the world approaches technology with the attitude that "it's made in the US, we'll use it". Bloggers in Africa use Blogger.com – they don't care that it's in California. They care that it's free, and they use it. That's not the case for Chinese blogs. A lot are using Chinese services like Blogbus. This is a really big deal when it comes to figuring out the censorship issue. The reason you see western companies building Chinese versions of their software is that otherwise the Chinese build Chinese versions. China is the one country where they're producing enormous amounts of their own technology and competing with US companies.

What are the effects of increased connectedness on our society?
There's an optimistic take that says the challenges we want to tackle today are global ones. Pandemics, global warming and poverty are all inherently cross-border. The interesting problems are international ones. At the same time, the internet frees us from the limitations of where we're born and where we grew up. As we build networks and friendships that cross boundaries, it stretches our sense of identity. When I get off an airplane, I can find other bloggers. My social circle now includes young hackers in Cambodia, as well as media professionals in Bahrain. My life is richer for it, but it also helps me think about the problems I want to solve in a really different way. For years, the environmental movement said "think globally, act locally". Now we can think globally and act globally.

And the downside of global connectivity?
In the short run, we look very parochial. We tend to adjust very slowly and ignore stuff we don't immediately understand. So few Americans have a real positive relationship with someone from the Arab world that they can lean on, for instance. As more and more of us forge connections like that, it gets harder and harder for people to make truly stupid global decisions. I can see arguments for how increasing connectedness could be a bad thing, but I just don't buy it. ●

Next by Michael Crichton, HarperCollins, ISBN 0007240996

GIULIANO BEVILACQUA/ARKIVFEATURES

TRANSFACT OR TRANSFICTION?

Blending scientific fact and fiction makes for startling plot lines. But combining a novel with a biotech policy guide is overambitious, argues **Peter Aldhous**

THERE are few appealing characters in *Next*, the latest techno-thriller from Michael Crichton, but readers will warm to Dave, the "humanzee" product of an illicit transgenic experiment. Smuggled from a primate research facility by his human "father", Dave loves his new family. The suburbs of southern California are, however, no place for a boy who is part-human, part-chimp – especially one whose response to a school bully is to climb a fence and throw excrement.

Like Dave, *Next* is an uncomfortable hybrid. In this assault on the commercialisation of biomedicine, Crichton takes some liberties in blending fact and fantasy. Lightly fictionalised accounts of genuine controversies are interspersed with mock news reports, some describing real people and events. Yet with improbable transgenic protagonists like Dave and Gerard – essentially a precocious child trapped in a parrot's body – there should be no mistaking this novel for a work of docu-fiction.

If the cover blurb is any guide, though, such ambiguity is exactly what Crichton was striving for. "This is not the world of the future – this is the world of right now," we are told. How many novels other than Crichton's recent offerings conclude with an "author's note" detailing policy recommendations? Together with the extensive bibliography, this suggests that Crichton sees *Next* as a serious commentary on the dangers posed by contemporary biotechnology.

By now, you may be dreading a rerun of *State of Fear*, Crichton's breathtakingly arrogant dismissal of global warming as a conspiracy theory. That novel, too, was embellished with a bibliography and author's message – which was lapped up by critics of action to combat climate change.

> "It is a shame that Crichton buys into the hype surrounding gene transfer"

While *Next* also has many flaws, it should prove less controversial. As a journalist whose beat overlaps with the novel's subject matter, I found much in it that I recognised, from the "bodysnatchers" caught raiding corpses for tissues to sell for use in surgery to the strange tale of a "bio-artist" charged by overzealous prosecutors with plotting bioterrorism. Crichton also tackles some important issues, notably the commodification of human genes and tissues and the blurring of the boundary between academic and commercial biomedicine. I share some of his concerns, which is perhaps why I found *Next* so frustrating. There is a good book in here struggling to get out, but Crichton seems so enamoured with his background research that he threw the whole lot at his word processor to avoid losing a single juicy anecdote.

Summarising this disjointed novel is almost impossible. *Next* is strongest when Crichton takes the time to develop plot lines that personalise the issues at hand. The pursuit of a lawyer and her child by bounty hunters intent on taking biopsies from their tissues to recover a biotech firm's intellectual property is an engaging device.

Mostly the chapters whiz past at breakneck speed, continually introducing new characters who fuse into a composite of dismal venality. Too often, proliferating sub-plots share the same fate as Gerard the transgenic parrot – who proves so annoying that he is ejected from a car and left lost and flapping in the middle of nowhere.

There are also sloppy errors. Some examples: embryonic stem cells are not found in umbilical cord blood; the glowing protein beloved of genetic engineers is GFP, not GPF; and African grey parrots, while reasonably intelligent, have not been shown to recognise their own reflections. In the faux news items, at least, Crichton has a get-out – perhaps he is satirising the ignorance of my profession. But one would expect someone who wears his bibliography on his sleeve to take more care.

From the standpoint of credibility, a bigger problem for me is that Crichton cannot resist some trademark science-run-amok. So alongside the sentient transgenic hybrids, we have drug addicts cured by a "maturity" gene, which then causes them to age prematurely. Dave and Gerard at least provide comic relief.

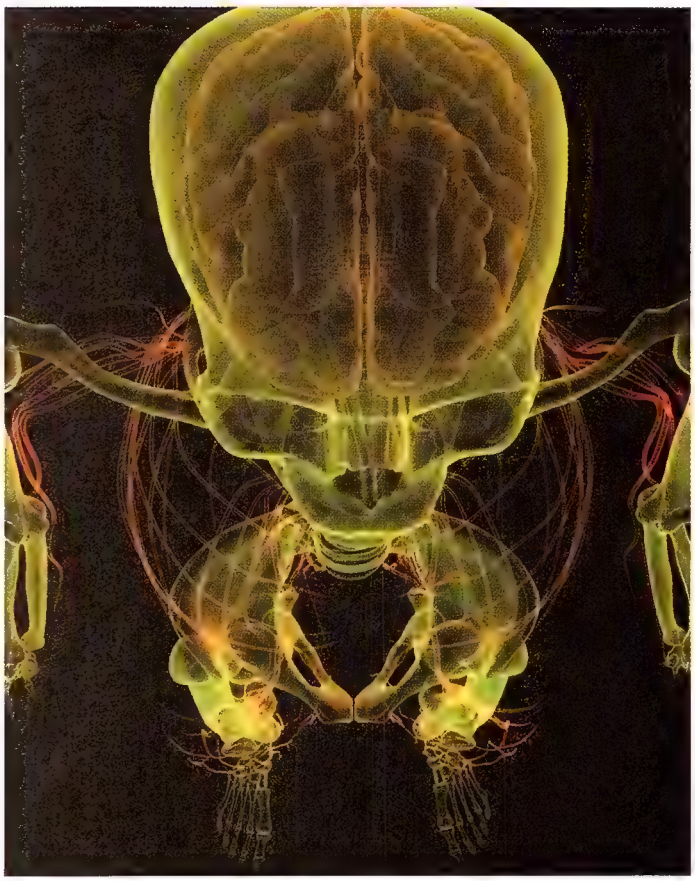
Given the wealth of material at his disposal, it is a shame that Crichton buys into the hype surrounding gene transfer, which if it worked so readily would already be routine. In truth, gene therapists are mostly running aground rather than running amok.

All in all, what *Next* needed was a tough edit. That would have been no easy job, given a superstar author who now seems to believe his own publicity. ●

Mind Wars by Jonathan Moreno, Dana Press, ISBN 1932594167

GETTING UNDER YOUR SKULL

Experiments designed to control the mind must meet proper ethical standards or else be condemned. But we should apply our judgements fairly, says **Jeff Hecht**



3DAMEDICAL.COM/GETTY

Research into reading the brain has a sinister past that dates back to the cold war

ROBORAT hit the headlines in May 2002. By remotely controlling the movement of a rat using electrodes implanted in its head, researchers demonstrated an impressive understanding of the brain, at least for rodents. Yet this was also a chilling demonstration of a type of mind control previously confined to the realm of science fiction.

Sponsored by the Pentagon's Defense Advanced Research Projects Agency (DARPA), RoboRat was the tip of an iceberg of military research on psychology, the brain and the nervous system. On the surface, the programme's goals sound laudable: defusing the actions of terrorists and insurgents, making soldiers more effective warriors, and helping the wounded recover. The research also promises potential spin-offs that could improve the medical treatment of a variety of physical and mental ailments.

Yet it's not that simple, writes Jonathan Moreno, director of the Center for Biomedical Ethics at the University of Virginia. During the cold war, military research on psychology and the brain took some ugly turns. Hoping to find ways to extract information from captured spies, military scientists and the CIA covertly dosed people with LSD and tried a variety of unsavoury experiments in psychological warfare that were preludes to the abuse at Abu Ghraib prison during the Iraq war.

Modern insight into the workings of the brain has led to more sophisticated research. Moreno briefly explains our understanding of the brain, and catalogues a number of projects conducted by DARPA, an agency that is relatively open in describing its activities. He says virtually nothing about classified programmes, other than to dismiss reports that the Pentagon has already developed tools to read and control our minds. Those claims may have been bluffs by intelligence agencies, or the delusions of conspiracy theorists.

The book comes alive when Moreno drops his scholarly objectivity to face old ghosts. His father was a psychiatrist whose sanatorium hosted trials of LSD in the 1960s. But what most seriously shook Moreno was learning several years ago of a link between one of his father's closest friends, Harvard psychiatrist Henry Murray, and Ted Kaczynski, who later became known as the Unabomber after murdering three people and wounding 23 others with letter bombs. In the 1950s, Murray studied how Harvard undergraduates including Kaczynski reacted to stressful attacks on their own beliefs. The experiment "could have left deep scars", Moreno writes. "It did not meet the ethical standards of the day." Clearly troubled, he asks, "Did the whole experience create the Unabomber? Unlikely, but it certainly didn't make Kaczynski more sanguine about science."

Once Moreno turns to the present, his scholarly objectivity returns, his passion fades, and he loses direction. Instead of a hard-hitting analysis of current programmes, he turns to the slippery distinction between mind and brain. His criticism of research is muted and the secrets exposed are few. He talks about programmes devoted to reading people's thoughts electronically and determining whether they are telling the truth, but doesn't probe the problems posed by conventional lie-detector tests. His concluding chapter wanders erratically between hope that ethics will be given more credence in future and concern that it won't.

Moreno knows his subject but pulls too many punches. You can feel him shudder when he tells of his reactions to Murray's abusive experiments, but too much of the book reads like the carefully balanced but soporific programme reviews issued by committees of eminent scientists. And it is disturbing to realise as the book draws to a close that it virtually ignores the possibility that this brave new mind science might be used to oppress people other than those universal bogeymen we label "terrorists". Although Moreno describes the pattern of intimidation and abuse of Iraqi prisoners at Abu Ghraib, he can't bring himself to blame it on anything more sinister than cold war psychology. He should have taken the same cold, hard look at his own colleagues as he did at his father's. **Jeff Hecht** ●

The pursuit of madness

If you live in a Zambian village and are diagnosed with schizophrenia, you are a lot more likely to recover than a New Yorker. Some Londoners with the disease are being offered cash incentives to encourage them to continue taking the unpleasant drugs that are still the main treatment. And more than 10 per cent of "well" people in surveys worldwide admit to hearing voices at some time. Don't worry, says Richard Bentall, contradiction and confusion are sometimes a good thing

THERE'S a revolution going on involving more than 150 million people from every part of the globe. If you hadn't noticed, that's hardly surprising because it is a very quiet revolution, involving marginalised, often stigmatised people. They are the millions who suffer from the devastating diseases of schizophrenia or bipolar disorder, or at least fit the diagnostic criteria of the International Classification of Diseases (version 10): F20 to F29, and F30 to F39, respectively, if you're a trainspotter in these matters.

For years there were just a few dissident voices: patients well enough to argue, their families, support groups and a handful of doctors. Now their cause is being taken up by a number of researchers in the UK, the US and elsewhere, who are developing a radical new approach to understanding and treating these diseases. This movement is challenging the fundamental assumptions that have driven psychiatric research into mental illness.

For most psychiatrists, schizophrenia and bipolar disorder are the most serious mental illness they will ever see. They are classed as psychotic disorders or psychoses, and they seem to involve a marked break with reality. During acute episodes, patients experience delusions ("the government is trying to kill me") or grandiosity ("I was the sole inventor of the helicopter and the pop-up toaster"). Some sufferers also experience hallucinations, usually voices criticising them or telling them what to do. The main difference between the two conditions is the apparent absence of emotion in schizophrenia, and the extreme emotions of bipolar patients, who seem to flip between depression and manic euphoria.

For over a century, investigators struggled to pinpoint the causes of these illnesses. New ideas were often stimulated by the accidental discovery of drugs that seemed helpful: antipsychotics such as chlorpromazine for schizophrenia, and mood stabilisers such as lithium carbonate for bipolar disorder. Progress has been slow, and few theories remained uncontested for long. Recovery, too, remains problematic, becoming a perverse kind of geographical lottery. In poor countries like Zambia, where psychiatric services are underdeveloped, recovery is about 50 per cent, while in the west it's about 30 per cent.

One of the biggest obstacle in the way of progress is the idea that these diseases are separate conditions. This dates back to the 19th century, mainly to the work of German psychiatrist Emil Kraepelin, who believed that patients with schizophrenia (or "dementia praecox" as he labelled it, meaning senility of the young) were suffering from a condition that would deteriorate and never get better. Patients with bipolar disorder (Kraepelin's "manic depression") generally had a much better outcome. Statistical analyses of symptoms show, however, that they do not cluster in the way Kraepelin imagined. In fact, very soon after schizophrenia and bipolar disorder became widely accepted as diagnoses, it became apparent that many patients experience both types of symptoms.

Recent studies by molecular geneticists have reinforced the emerging consensus that schizophrenia and bipolar disorder are overlapping conditions. No important genes or gene clusters "for" either disease have ever

Profile

Richard Bentall is professor of psychological medicine at the University of Manchester. He is a long-standing critic of established views of psychosis, arguments he develops in his book *Madness Explained* (Allen Lane)

MARINA GIANNOBILI/MILLENNIUM

been found. The best it gets is that defects in the actions of some genes – for example, *neuregulin-1* or *dysbindin* – seem to slightly increase the risk of suffering from symptoms associated with both conditions.

Another challenge is that the dividing line between psychosis and normal functioning has become increasingly fuzzy.

One very surprising discovery is that "psychotic" symptoms are far more widely experienced than anyone thought. These symptoms are mostly auditory hallucinations, which, with delusions, are likely to clinch a diagnosis of schizophrenia or bipolar disorder for about 1 per cent of the population. But studies in the west show that about 10 per cent of the population experiences auditory hallucinations at some time in their lives.

This makes sense if there is a spectrum from psychosis to normal, with no clear dividing line between "normal" and "sick". On an optimistic note, it also suggests that many people cope with psychotic symptoms without seeking medical help.

Faced with these difficulties, psychologists now focus on specific symptoms. A lot of research, for example, links auditory hallucinations to inner speech, or verbal thought. Children learn to think in words by talking aloud to themselves. In adulthood, a neuromuscular echo of this persists as covert electrical activation of the speech muscles during thinking, called subvocalisation. Philip McGuire at the Institute of Psychiatry (IOP) in London, among others, used imaging studies to show that patients subvocalise when they hallucinate about hearing voices, which suggests that they can't distinguish between their thoughts and external stimuli. Although no one understands the causes, there is some controversial evidence that trauma is involved. A 2005 study by Tony Morrison at the University of Manchester, and a study I published in 2003 both show very high rates of sexual abuse in patients who hear voices.

> "About 10 per cent of the west's population will experience auditory hallucinations in a lifetime"

When it comes to delusions, cognitive psychologists have tried to identify abnormal reasoning processes that may lead to false inferences about the world. Paranoid (persecutory) delusions have received a lot of attention, and there is evidence these delusions follow long-term experiences of actual persecution and victimisation, perhaps leading to hypersensitivity to threat stimuli.

There is also evidence that more basic cognitive difficulties are involved. Philippa Garety at the IOP ran an experiment in which she showed patients two jars, one containing white beads mixed with a few red, and another red with a few white beads. The patients were then shown a sequence of beads, without knowing which jar they came from. Those with persecutory delusions made a guess at which it was (often wrongly) more quickly than did non-deluded patients.

As well as jumping to conclusions, people with persecutory delusions also experience difficulty understanding the thoughts, feelings and beliefs of others. It seems likely that some combination of these difficulties leads to full-blown paranoia.

All this research is very promising: we really are beginning to tease apart symptoms that previously looked like a big jumble. As a result, psychological treatments for people suffering from psychosis are a real possibility. Old views will take some changing, though.

After the advent of antipsychotic drugs, and the failure of psychoanalysis, psychiatry was clear: psychological treatments were not for schizophrenia or bipolar disorder. Drugs it was, and largely still is, leaving the problem of how to encourage those 20 to 50 per cent of patients who stop taking the drugs to persist. Newham Centre for Mental Health in east London, for example, recently tried a controversial scheme where it paid between £5 and £15 to people with schizophrenia each time they had a new "depot" injection of psychiatric drugs, usually once a month.

People often stop taking these drugs because of their unpleasant side effects, and the drugs are sometimes ineffective. So psychologists in the UK have braved disapproval to experiment with shorter-term psychological therapies. In particular, cognitive behaviour therapy (CBT) is used to help patients identify and evaluate reasoning processes that drive their psychotic thinking. This might take the form of asking them to find evidence for their beliefs and carry out experiments to test this evidence.

More excitingly, the UK's Medical Research Council is funding a £1.5 million clinical trial (I am one of the investigators) to find out whether CBT can prevent people who show the very earliest symptoms of illness from developing full-blown psychosis.

It is too early to say where these new developments will lead, but optimists like me think that it may be possible to abandon altogether psychiatric diagnoses such as schizophrenia, once all of the symptoms of psychosis have been adequately explained. In the UK, most psychiatrists have come to see CBT as playing some role in treating patients, although they still believe that good drug treatment is essential. In the US, psychiatrists remain generally more sceptical.

Whatever the role of CBT, schizophrenia and bipolar disorders will never be the same again. This can only be a good thing. After all, no one likes an intellectual muddle, while everyone loves as much choice as possible when it comes to treatment. ●

The word

The monster

ON A fateful night in 1832, French mathematician Evariste Galois scribbled down the details of a new kind of mathematics called group theory. The very next day he died, age 20, shot in a duel over the woman he loved. But his work lived on, becoming one of the foundations of mathematics. Now it seems Galois' group theory may provide a surprising insight into the nature of the universe itself. And it all comes down to an unlikely suspect: the monster.

The history of the quest to find the monster is detailed in a new book by Mark Ronan (*Symmetry and the Monster: One of the greatest quests of mathematics*, Oxford University Press, 2006). It all begins with Galois' group theory, the mathematical language of symmetry. An object has symmetry if it is left unchanged by some kind of transformation. For example, an equilateral triangle remains unchanged if you rotate it about its centre by 60, 120 or 360 degrees. In physics, many of the laws of nature are symmetrical. That is, they work equally well in Ohio as in Singapore and they still work if the equations undergo complex mathematical transformations.

The sets of transformations that leave the laws of physics unchanged are called symmetry groups. Physicists believe that the key to understanding the universe is to discover the symmetry groups that describe the very foundations of reality.

NASA/STSCI/AURA/ESA

> "It is so huge that its discovery took 10 years of feverish work"

Many symmetry groups have been discovered, but the ones called "finite simple groups" are most fundamental. That's because they do for symmetry what primes do for numbers. Like the primes, finite simple groups cannot be broken down into more fundamental units, rendering them the building blocks of symmetry.

Enter the monster. Many of the finite simple groups fit into a neat pattern, similar to the way atoms fit into the periodic table of elements. But 26 renegade groups refuse to fit the mould. The monster is the largest of these renegades, a group of rotations in a mind-bogglingly complex space with 196,883 dimensions. The monster is so huge that it took 10 years of feverish work before its discovery was finally announced in 1982.

Nobody knows why there are 26 of these unruly groups, but some theorists suggest they may play a role in understanding the universe at the deepest level. They believe that the best stab we have at a so-called theory of everything is an idea based on symmetry called string theory. If string theory is correct, the universe may have 26 dimensions – the same number as those mysterious groups.

Coincidence? We don't know. All we can hope for is a genius of the stature of Galois to find the ultimate pattern and finally tame the monster. ●

Enigma

Small cubes

No. 1426 Keith Austin

EACH day, Lucas is given a cube of metal whose side is between 9.5 and 10.5 metres. He melts the cube down and forms the metal he obtains into a number of small cubes whose sides are all between 9.5 and 10.5 centimetres. At the end of Monday he wrote down the number of small cubes he had made; it was a 6-digit number, abcdef. After doing some calculating, he announced that that was the smallest number of cubes he could make in a day. That evening, as Lucas was a puzzle fan, he composed the addition sum below, where abcdef is the number of small cubes. Each of the capital letters represents a digit, the same digit for each occurrence of that letter. Send in RUST.

$$\begin{array}{r} R\,S\,T\,S\,T\,S \\ +\;R\,T\,R\,U\,T\,T \\ \hline a\,b\,c\,d\,e\,f \end{array}$$

£15 will go to the sender of the first correct answer opened on Weds 21 February. The Editor's decision is final. Please send entries to Enigma 1426, New Scientist, Lacon House, 84 Theobald's Road, London WC1X 8NS, or to enigma@newscientist.com (please include your postal address). The winner of Enigma 1420 is Ivan Simmons of Edinburgh, UK.

Answer to 1420 $a^2 + b^2 + c^2$ 62, 77, 122, 98.

Bookends

A star is reborn

Nightwatch (4th edition)
by Terence Dickinson, Firefly,
ISBN 9781554071470
Reviewed by Ivan Semeniuk

ONCE, curious readers wanting to learn about the night sky were confronted with tomes full of baffling numbers, jargon, and star charts that seemed to bear no resemblance to the real thing. Then came *Nightwatch*, a clear, concise manual for backyard stargazing that also managed to convey the excitement of astronomy. This fantastically revised edition continues that tradition, but now includes sky maps for observers in the southern hemisphere and a guide to celestial phenomena up to 2018. The best introduction around.

Injecting reality

Vaccine
by Arthur Allen, W. W. Norton,
ISBN 9780393059113
Reviewed by Bernard Dixon

THE history of vaccines is full of unexpected twists. While immunisation experts may feel they do not need journalist Arthur Allen to urge them to remember such twists, and will certainly reject suggestions that polio eradication diverts resources from more important goals, this is a well-researched portrayal of immunisation, from the earliest pioneers to an arm of preventive medicine now thoroughly entangled in politics, commerce and public relations. A vivid corrective to the idealised, wholly triumphant version of the development of vaccines.

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If you're passionate about cutting-edge, ethical research, talk to Mars. The world's leading pet nutrition centre, based in glorious countryside, explores opportunities to understand and improve companion animal health through nutrition. It's a fantastic environment where hundreds of cats, dogs and birds sample our global brands (such as Whiskas® and Pedigree®) while receiving 100% care from experienced handlers. And we mean 100%. Anything short of luxury and our animals won't provide the vital feedback – glossy coat; excellent teeth; happy, healthy temperament – that we're striving for.

This is a chance to become part of a global research team that's renowned for promoting the optimal health of pets. What's more, you'll have access to state-of-the-art laboratories utilising the latest technology to employ cutting-edge techniques. Just think about the impact of your work: our products feed a quarter of the world's pets. (And there are 6 million cats and 5 million dogs in the UK alone.) It's a rare, high profile, exciting opportunity, however you decide to join us.

Project Scientist • c.£29,300

With experience of vascular biology, you'll design, direct and manage nutrition based research projects as part of a project team, providing appropriate analysis and reporting of data to ensure the development and success of research opportunities. You will ideally have a PhD in Vascular Health or a related field; with proven experience in a research environment and track record in scientific reporting, publishing and presenting. **Ref: WAL00032.**

Laboratory Technician • c.£20,000

With an in-depth understanding of method and development in analytical chemistry instrumentation such as GC-MS, HPLC etc., you'll become part of a team of technicians experienced in a number of disciplines: Tissue Culture, Molecular Biology, Biochemistry, Immunology, Microbiology or Analytical Chemistry. You will need a minimum of science A-levels or preferably a chemistry degree and experience in a laboratory environment utilising analytical chemistry instrument techniques. **Ref: WAL00029.**

For both roles you will also receive a benefits package that includes an excellent pension scheme, life assurance and private health care. To apply, please visit www.mars.com/careers using the appropriate job reference number and searching under 'R&D'. Alternatively, send your cv to Julia Woodley, Personnel Department, Mars, Dundee Road, Slough SL1 4JX. Closing date: 8th November 2007.

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CSIRO

Theme Director - Food Safety and Quality

Attractive Remuneration Package
Location Negotiable
Reference Number: 2006/1601

An outstanding opportunity exists for an experienced and motivated individual to fill the role of Theme Leader - Food Safety and Quality which aims to improve the safety of Australia's food chain by developing new food safety management techniques, improved methods of controlling food safety hazards and identifying food quality attributes that appeal to consumers.

You will have direct responsibility to the Chief Executive Officer for successful execution and management of the Theme recommending strategic direction and overseeing the integration and delivery of the science. The Theme Leader will need to be strongly client and outcome focused, with a demonstrated ability to lead strategic science projects, be innovative and a self starter who excels in complex environments. You will have experience interacting with people from a wide range of disciplines across all levels, proven ability of building partnerships and have excellent communication, organisational and coordination skills. You will have demonstrated senior level expertise in a science environment and have a reputation for achieving results.

This position may be located in either: Brisbane QLD, North Ryde NSW, Werribee VIC or Adelaide SA.

For selection documentation and details on how to apply visit **www.csiro.au/careers** or phone 1300 301 509.

Dunedin, New Zealand

Stuart Chair of Science Communication

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo

Centre for Science Communication

Applications are invited for an appointment to the Stuart Chair of Science Communication, the endowed foundation Professor of a newly formed Centre for Science Communication at the University of Otago. The Centre is administratively located in the Division of Sciences but will have strong links to the other three academic divisions. The Chair will be the senior academic leader and Director of the Centre, charged with its national and international development and with ensuring that the Centre is committed to excellence in all its activities.

The successful appointee will be passionate about communicating science and its promotion and popularisation in the community. They will have an exemplary international research reputation, a capacity to provide academic vision and strategic leadership, and the ability to work with staff from diverse academic and cultural backgrounds. It is expected that links with other academic units throughout the University will be initiated and fostered, and that strong associations with the appointee's primary research area will be maintained to promote continued scholarship there as well as publications directed at science communication.

Further information about the University of Otago can be found at http://www.otago.ac.nz

Specific enquiries may be directed to Professor Vernon Squire, Pro-Vice-Chancellor, Sciences, Tel 64 3 479 7977, Email vernon.squire@otago.ac.nz

Reference Number: A06/214. **Closing Date: Wednesday 31 January 2007.**

APPLICATION INFORMATION

With each application you must include an application form, an EEO Information Statement, a covering letter, contact details for three referees and one copy of your full curriculum vitae. **For an application form, EEO Information Statement and a full job description go to: www.otago.ac.nz/jobs** Alternatively, **contact the Human Resources Division, Tel 64 3 479 8269, Fax 64 3 479 8279, Email** job.applications@otago.ac.nz

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Australian Government
Department of the Environment and Heritage

COMMONWEALTH ENVIRONMENT RESEARCH FACILITIES (CERF)

Call for applications for Fellowships and Significant Projects

The Australian Government Department of the Environment and Heritage invites applications for research fellowships and significant research projects under the second funding cycle of the CERF programme.

Research fellowship applications are sought from world-class scientists (Australian or international) to work within an Australian institution. Significant project applications are sought from existing Australian research institutions for research of up to three years.

CERF targets world-class, public good, collaborative research that focuses on CERF priority research areas. It is primarily aimed at areas that have not yet received substantial assistance and encourages co-investment.

This funding round will be based directly on applications and will not have an expression of interest phase. For further information, including application guidelines and forms, visit: **www.deh.gov.au/cerf/**

Applicants are required to submit an online application form:

- fellowship applications should be submitted to **CERFfellowships@erin.gov.au** by **close of business on Friday 16 February 2007**
- significant project applications should be submitted to **CERFprojects@erin.gov.au** by **close of business on Friday 16 March 2007**.

For further information, please email **cerf@deh.gov.au** or phone on 02 6274 2284.

hmaC057269

Feedback

IT HAS to be one of the greatest losses of all time to journalism, to history, to human culture. One of the buildings hit with anthrax spores in 2001, by a bioterrorist who is still at large, was the headquarters of *The National Enquirer* and its sister paper, the *Weekly World News*, in Boca Raton, Florida. Before anyone realised the risk, vacuum cleaners had blown the tiny, tough spores throughout the building, which eventually had to be gutted and disinfected. Sometime this month it will open again. But in a loss that must rank with that of the ancient Library of Alexandria, the two papers' unique photo archive is now gone.

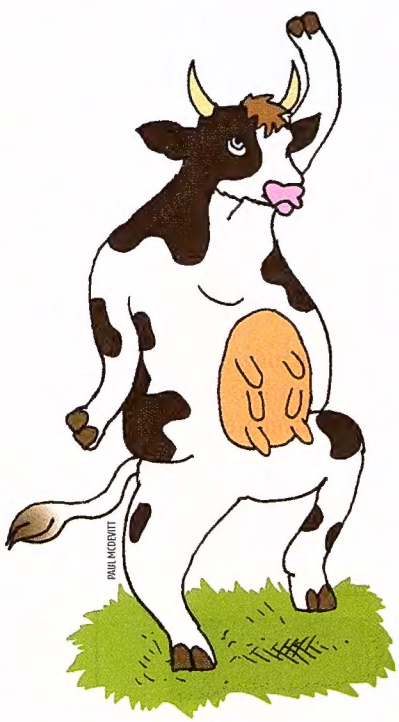
Photos in the archive gave the papers scoop after scoop. Bigfoot captured. Elvis with the waitress he married in 1992, 15 years after he "went into hiding". Proof that Washington think tanks are riddled with space aliens. The ape that had a human baby. The Loch Ness monster captured, then released so that it could give birth. And of course regular sightings of Bat Boy, from his discovery in a West Virginia cave in 1992 to his endorsement of Al Gore in the 2000 presidential election. Most poignantly of all, the confessions of Bigfoot's love slave, published after the anthrax attacks but before the building was closed down.

Now these photos are no more. But let us salute our journalistic colleagues who struggle on nonetheless, still telling the truth to supermarket checkout lines everywhere. This week the *WWN* carries, not just photo but video evidence of a Philadelphia bride abducted by space aliens. Go for it, guys! Don't let the terrorists win!

AND here's a story for the fearless hacks of Boca Raton to get working on, as we here at Feedback strongly suspect alien involvement. Farmers in Ontario, Canada, have been having trouble with their cattle, according to reports in the Toronto newspaper *The Globe and Mail*.
The animals have been giving less milk, kicking and, the farmers swear, dancing – or as one puts it, standing up in their stalls to "wiggle their back ends".

The farmers blame this unusual behaviour on stray voltage, which builds up on farm surfaces, we are told, because electrical utilities are sloppy about how they install transformers and wiring, allowing currents to flow to ground where they shouldn't. This, the farmers say, creates electric fields that are generally too small for humans to feel – but a big animal like a cow has more voltage across itself in such a field than a human and feels a tingle.

The farmers are so upset that the law may soon be invoked to force the utilities companies to install things more carefully – and while they are at it, the farmers suggest, they might relearn what they were taught in their first-year electrical engineering classes.
We're not sure this is the whole story, though. Dancing cows? Stray voltages? Has anyone checked for corn circles as well?



While searching for the phone number of his local law enforcers, Will Allen was offered the opportunity to "buy Cowley Police Station on eBay". Just as well he's a law-abiding citizen

FROM the University of Oxford's online advice to people thinking of applying to study there: "Colleges receive around four well-qualified applicants per place, so on average two-thirds of those interviewed cannot be offered a place." Robert Sheehan wonders if these figures apply to the mathematics course.

AN Australian company called New Water sells products and services aimed at helping its customers save water. One such, reader Robert Anker notes, is Aqua Reviva, which gives New Water's newsletter the opportunity to propose one of the strangest units of measurement we have yet come across: "Aqua Reviva has the potential to save homes 500 litres of water per day. This, applied to the 125,000 new homes built around Australia each year, saves 62 million litres of water per day. This is equivalent to an Olympic-sized swimming pool stretching from Melbourne to Darwin."

The mind boggles at the idea of an Olympic race staged in this 4000-kilometre-long pool.

READER Stan Courtney tell us that while browsing through *Scientific American* he came across this in an article about autism: "For neuroscientists, this finding... represents a dramatic change in the way we understand the way we understand."

Courtney says he cannot remember seeing any other sentence like this, in which a repeated phrase actually makes sense. Has anyone else?

FINALLY, Kevin Dickens has a room in a hall of residence at the University of Nottingham in the UK. On the inside of the door is a notice that reads: "Remember to always close the window and lock the door before leaving the room." Dickens wants to know how he is then supposed to get out.

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

The last word

Last Words past and present, plus a full list of unanswered questions, are available on New Scientist's website at www.newscientist.com

KEEPING PACE

If I was poisoned with a drug to stop my heart beating, would my pacemaker keep me alive?

It depends on the circumstances. Drugs affecting the heart's ability to contract act either on the specialised electrical conduction systems that trigger a heartbeat or on the ability of the heart muscle to generate contractile force. In the former case, a pacemaker will continue to stimulate cardiac contractions even when its intrinsic electrical activity has been suppressed. In the latter, the drugs will prevent the heart muscle from contracting, so the pacemaker will not keep the heart beating. Cardioplegia, the technique used to paralyse the heart during open-heart surgery, uses the latter approach. Once beating ceases, surgeons can add bypass grafts or replace valves. When the cardioplegia is reversed, the heart muscle resumes its contractions.

Rafe Chamberlain-Webber
Consultant cardiologist
Edge, Gloucestershire, UK

BOUNCE BACK

When a car crashes and its protective airbags are inflated, where do the airbag covers go to stop them breaking your nose?

Airbag covers are formed from moulded plastic and have lines built into them that are much thinner than the rest of the cover. When the airbag inflates, it forces its way through the covers, which fracture along these very thin lines. Obviously, it is important that the cover does not become a projectile, so it also has other thin sections which act as hinges. These hinges ensure that the fractured sections of the cover rotate harmlessly away from the occupant, rather like a pair of barn doors swinging open. These thin hinge lines and fracture lines are often visible, sometimes looking like a large "H" (especially in older or less expensive cars).

"Airbag technology is one of the most important improvements in car safety, but an improperly used airbag can do more than break your nose"

Airbag engineers pay particular attention to the design and fixing of any logos or manufacturers' badges which are fitted to the cover in the centre of the steering wheel to ensure that the badge remains attached to one of the doors formed by the opening of the cover, instead of coming loose and causing injury.

In the case of side-impact airbags contained within the seat, a similar effect is achieved by providing a weakened seam of stitching in the seat cover, immediately alongside the airbag. This is one good reason not to fit seat covers.

Airbag engineers also have to ensure that the rapidly unfolding envelope of the bag moves straight towards the person it is supposed to protect, rather than across the driver's or passenger's face and chest. This involves very careful analysis of folding patterns, predictive software and analysis of high-speed photography from test firings. Engineers have also learned a great deal from origami.

Ian Gordon
Carlisle, Cumbria, UK

Airbag technology is one of the most important improvements in car safety, but an improperly used airbag can do more than break your nose. Cover flaps are made of light plastic, ductile at working temperatures and designed to rupture to let the bag through as it expands. Fragments have been known to cause injuries, especially to the face, but these are usually mild. Nearly all airbag injuries result from the victim being too close to the airbag, or wearing a seat belt improperly. Some of the worst injuries result from putting a child in an improperly placed seat, or carrying them on an adult's lap, which in some countries is now a criminal offence.

Remember that an airbag deploying is like a bomb going off in your vehicle. If you are too close to the explosion, you may be harmed by impact, blast, fragments or even caustic residues. If you are at least 25 centimetres away from the cover flap, properly seated, with your seat belt taut and correctly placed over your hips and shoulder, airbags are excellent. In this case, airbag injuries should be the least of your worries in an accident.

"Remember that an airbag deploying is like a bomb going off in your vehicle, so you may be harmed by impact, blast, fragments or caustic residues"

Jon Richfield
Somerset West, South Africa

You can see a picture of an already deflated airbag, with the split in the covers clearly visible, at: http://upload.wikimedia.org/wikipedia/commons/2/20/Airbag_SEAT_Ibiza.jpg

Simeon Verzijl
McKinnon, Victoria, Australia

THIS WEEK'S QUESTIONS

A pox on us

Why aren't we concerned about a mild virus such as chickenpox mutating into something far worse, when there is such a fuss about the possibility of bird flu virus doing so? What is it about chickenpox that means it has remained stable down the centuries, while flu viruses have mutated almost yearly?

Jane Richards
St Albans, Hertfordshire, UK

Kaboom squared

I've just got back from a fireworks display where some of the fireworks exploded into a square shape. How do they do that?

Justin Muller
Tokyo, Japan

Life after death

Why do hair and fingernails grow after death? Surely dead means dead. How can our bodies continue to produce more cells?

Shannon Smith
Bermuda

Questions and answers should be kept as concise as possible. We reserve the right to edit items for clarity and style. Please include a daytime telephone number and a fax if you have one. Questions should be restricted to scientific enquiries about everyday phenomena. The writers of all answers that are published will receive a cheque for £25 (or the US$ equivalent). Reed Business Information Ltd reserves all rights to reuse question and answer material submitted by readers in any medium or format.

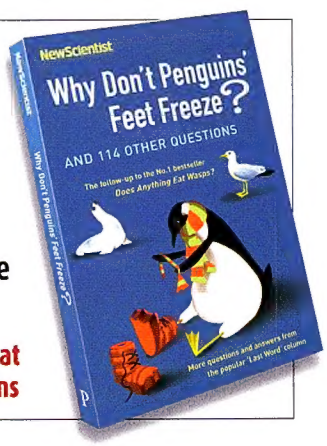
Send questions and answers to The Last Word, New Scientist, Lacon House, 84 Theobald's Road, London WC1X 8NS, UK (fax +44 (0) 20 7611 1280) or by email to lastword@newscientist.com (all correspondents should include their postal address in order to receive payment for answers). If you would like a complete list of all unanswered questions please send an SAE to LWQlist at the above address.

Memorable answer? The Last Word and New Scientist have teamed up with Crucial Technology (**www.crucial.com/uk**) and will be awarding each successful author a 512MB Gizmo! overdrive.

WHY DON'T PENGUINS' FEET FREEZE?

The latest collection from The Last Word, answering some of the world's most baffling questions

Available in bookstores and online at www.newscientist.com/lastword3.ns



CAN YOU TELL WHERE IT'S BEEN

JUST FROM ITS SPOTS?

The Rolex Awards for Enterprise

Marine conservationist Brad Norman can. He's developed a photo-identification system that identifies individual whale sharks from the unique set of spots on their skin, enabling him to chart their migratory routes and so aid their conservation. He's just one of the five 2006 Rolex Laureates whose groundbreaking endeavours have been selected by a panel of distinguished judges for their potential to expand human knowledge or improve the lot of mankind. The winners each receive a gold Rolex chronometer and US $100,000 towards the completion of their projects. Which, for Brad Norman, will mean that one day we'll know where every whale shark's been just from its spots.

CHANDA SHROFF
Reviving Kutchi embroidery and thereby the fortunes of local women.

RORY WILSON
Inventing an energy-use monitor to help safeguard endangered species.

ALEXANDRA LAVRILLIER
Preserving the nomadic culture of the Evenk through a nomadic school.

BRAD NORMAN
Creating a whale-shark recognition system to aid its conservation.

PILAI POONSWAD
Saving Thailand's hornbills from the threat of poaching and deforestation.

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THE 2006 ROLEX LAUREATES

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